KONIG

OS25D

MODEL

SERVICE MANUAL

Precautions for Use

1. Inspect the shipping carton for shipping damage. If you notice damage, notify the carrier immediately.

2. Before you apply power to the Oscilloscope, make certain that the voltage selector plug on the rear panel has been inserted with the arrow head at the proper line voltage. Also check the fuse to be sure it is of the proper rating.

3. Do not leave a bright beam on the CRT screen for long periods. This can cause permanent damage to the screen phosphor.

4. This instrument is convection cooled. Do not block the cooling vents when you are operating it.

5. To insure stable operation over long periods of time, do not subject the Oscilloscope to vibration, direct sunlight, extreme temperature variations, high humidity, dust, or electromagnetic fields.

6. Replace the line cord with only a properly rated, 3-wire cord.

7. The GND (ground) terminal and outer ring of all front panel BNC connectors are connected to chassis (earth) ground.

   ⏚ This symbol indicates chassis ground.

8. ⚠ This front and rear panel warning symbol indicates there are limits that must not be exceeded at these inputs. Refer to "Specifications."

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INTRODUCTION

The Heath Model SO-4552 Oscilloscope is a laboratory-grade instrument that is ideal for the wide range of measurements typically found in electronics, development, and scientific research laboratories. Some of its outstanding features are:

- Dual trace.
- 25 MHz bandwidth (10 MHz at 1 millivolt/division).
- 18 ns vertical rise time.
- 1 millivolt/division sensitivity.
- High-brightness mesh CRT with internal graticule.
- Inverting input switch on channel B.
- Algebraic add function.
- Sync filtering for stable display of TV signals.
- Independent channel A and channel B triggering for asynchronous input signals.
- Beam finder.
- Graticule illumination.
- Built-in component tester.

The attenuator networks of each channel have 10 calibrated ranges, from 5 millivolt/division to 5 volts/division. The sensitivity of each range can be increased by 5 when you pull the X5 switch.

The display for the channel B input can be added to the display for channel A either directly or inverted. This feature allows differential signal measurements (that is, channel A minus channel B).

Calibrated time-base ranges from .2 seconds/division to 100 nanoseconds/division are switched in a 1-2-5 sequence. Any sweep speed can be expanded 10 times when you pull the X10 MAG switch.

The Trigger Source switch selects channel A, channel B, line frequency, or an external signal as the source for triggering the trace sweep.

The Trigger Coupling mode switch selects sweep triggering that is automatic (self-triggering), normal (manually adjusted using Trigger Level), or optimized for TV vertical or horizontal repetition rates.

The Slope switch and Trigger Level control allow the waveform to be precisely triggered at any point along its positive or negative slope.

To frequency compensate probes, a calibrated 2-volt peak-to-peak 1 kHz square wave signal is provided at a connector on the front panel.

A selector plug on the rear panel allows you to match the power transformer to standard line voltages (110/125 or 220/240 VAC).

While the solid-state circuitry provides excellent sensitivity, stability, and versatility, the rugged construction and dependable operation of this Oscilloscope make it an indispensable tool for the critical hobbyist, service technician, or professional.

SPECIFICATIONS

NOTE: The following specifications apply at 50° to 95° F (10° to 35° C) at 10 to 80% R.H.

VERTICAL DEFLECTION

Deflection Factor	5 mV to 5 V/DIV; 10 steps in 1-2-5 sequence with variable control.
Magnification	5 times increase in sensitivity of selected range (provides 1 mV to 1 V/DIV).
Accuracy (1 kHz)	±3% at CAL'D position; ±5% at CAL'D position for X5 gain.
Bandwidth (referenced to 5 divisions at 50 kHz)	DC to 25 MHz (at –3 dB). DC to 10 MHz (at –3 dB) on 1 mV/DIV range.
Rise Time (referenced to 5 divisions)	Approximately 18 ns.
Overshoot	Less than 5%.
Input Impedance	1 MΩ shunted by 25 pF ±10 pF.
Maximum Input	400 V (DC + AC peak).
Operating Modes	CHA, CHB, DUAL (ALT or CHOP), and ADD.
Chop Frequency	Approximately 500 kHz.
Channel B Polarity	Waveform inversion selectable.

HORIZONTAL DEFLECTION

Triggered Operation

Sweep Time	.2s to .1 µs/DIV; 20 steps in 1-2-5 sequence with variable control.
Magnification	X10 (provides sweep expansion to 10 ns/DIV).
Accuracy	±3% at CAL'D position except ± 6% on .2 s and ±20% on .1 µs. Add ±3% when using X10 magnifier.
Trigger Holdoff Time	Adjustable to longer than 5 times full-width sweep length on all ranges.

X-Y Operation

Inputs	Channel A: X-axis. Channel B: Y-axis.
Sensitivity	Same as channel A and channel B deflection factor switch setting on corresponding axis.
Frequency Response	DC to 1 MHz (at –3 dB).
Phase Shift	Less than 3° at DC to ~100 kHz.

TRIGGER

Source	CHA (channel A), CHB (channel B), LINE (line frequency), and EXT (external).
Coupling/Sensitivity	
AUTO	100 Hz – 30 MHz: 1.5 DIV (internal); ≥ .1 V p-p (external).
NORM	DC – 30 MHz: 1.5 DIV (internal); ≥ .1 V p-p (external).
TV-V	20 Hz – 1 kHz: .5 DIV (internal); ≥ .05 V p-p (external).
TV-H	1 kHz – 100 kHz: .5 DIV (internal); ≥ .05 V p-p (external).
Slope	Normally "+"; pull TRIG LEVEL control for "–" .
External Input	Input impedance: 1 MΩ, 30 pF. Maximum input voltage: 300 V (DC + AC peak).

COMPONENT TESTER

Test Voltage	Maximum 6 V rms (open circuit).
Test Current	Maximum 11 mA (shorted).
Test Frequency	Line frequency.
Components	Capacitors, inductors, diodes, transistors, etc.

DIGTAL MULTIMETER(PS-257 only)

Display	3½ dight LCD dispaly maximum reading 1999.
Sampling Rate	Twice per second.
Over Range Indication	*LCD will show a"1"flashing in the highest position accompanied with a continuous buzz. (except OHM range)*
Polarity	Automatic polarity"-"display for negative input.

DC VOLTAGE

Range	Resolution	Accuracy	Input Impedance	Overload Protection
200mV	100μV	± (0.3%rdg+1dgt)	>100MΩ	DC 1100V
2V	1mV		Approx 11MΩ	
20V	10mV	± (0.5%rdg+1dgt)	Approx 10MΩ	AC 800V
200V	100mV			
1000V	1V			

AC VOLTAGE

Range	Resolution	Accuracy (40Hz~500Hz)	Input Impedance	Overload Protection
2V	1mV	± (0.5%rdg+5dgt)	Approx 11MΩ	DC 1100V
20V	10mV	± (1%rdg+5dgt)	Approx 10MΩ	AC 800V
200V	100mV			
750V	1V	± (2.5%rdg+5dgt)		

RESISTANCE(Ω)

Range	Resolution	Accuracy	Max.Open Circuit Voltage	Overload Protection
200Ω	100mΩ	± (0.8%rdg+2dgt)	0.45V	250V DC/AC
2KΩ	1Ω			
20KΩ	10Ω			
200KΩ	100Ω			
2000KΩ	1 0KΩ			

CONTINUTY (•ıı))

Range	Resolution	Buzzer Range	Max.Open Circuit Voltage	Overload Protection
•ıı)	1Ω	approx below 300Ω	0.45V	250V AC/DC

DIODE (⊣◀)

Range	Resolution	Accuracy	Max.text Current	Max.Open Circuit Voltage	Overload Protection
⊣◀	1mV	± (0.8%rdg+2dgt)	0.8mA	1.7V	250V AC/DC

GENERAL

Calibration Signal	2 V p-p; ±3%; 1 kHz square wave.
Beam Finder	Compresses deflection to aid in locating an off-screen trace.
Graticule Illumination	Adjustable lighting around CRT to enhance graticule visibility.
Trace Rotation	Front panel adjustment to compensate for normal, external magnetic fields.
CRT Type	8 x 10 divisions with internal graticule.
CRT Phosphor	P31.
Operating Environment	32° to 122° F (0° to 50° C); 10% to 80% R.H.
Storage Environment	–22° to 158° F (–30° to 70° C); 10% to 90% R.H.
Power Requirements (see rear panel)	90-137 VAC or 198-264 VAC, 50/60 Hz, 40 W.
Dimensions	14-1/2" W x 7" H x 17-1/4" D (37 x 18 x 44 cm).
Weight	17.2 lbs. (7.8 kg).

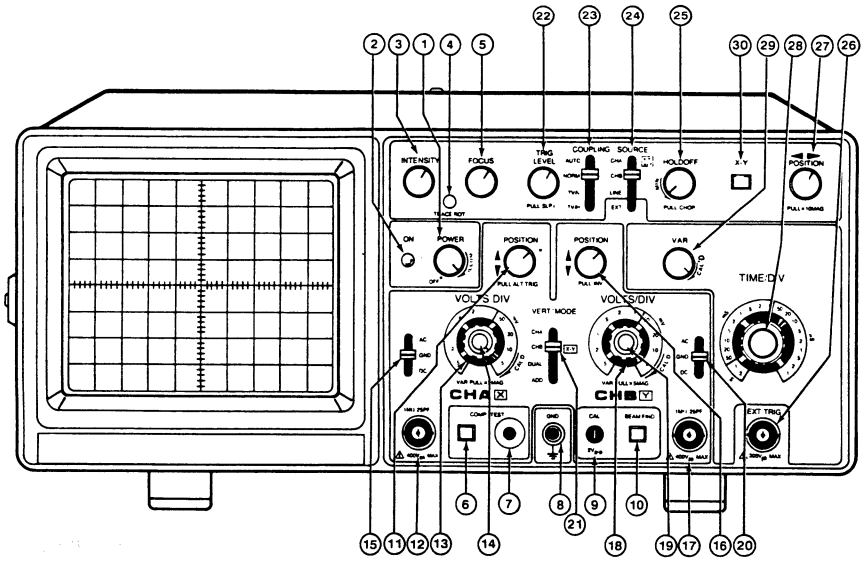


Figure 1

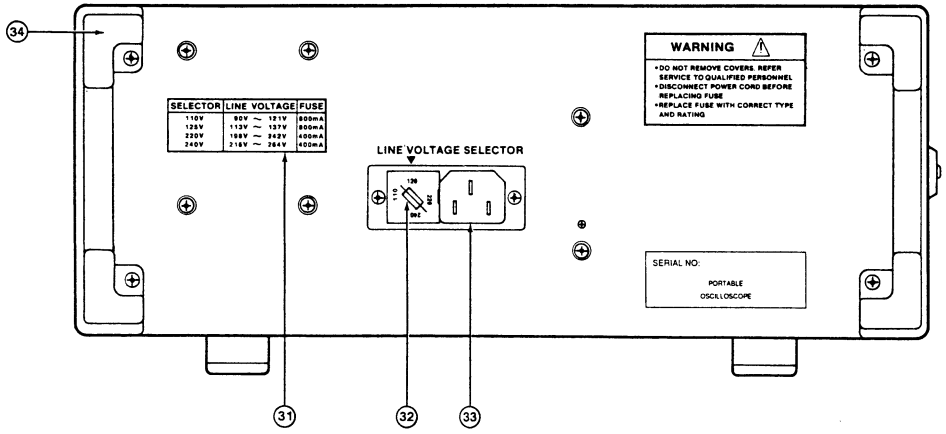


Figure 2

OPERATION

CONTROLS AND CONNECTORS

Refer to Figure 1 and Figure 2 as you read the following paragraphs. The number at the beginning of each paragraph corresponds to the circled number on the illustrations.

General

1. POWER — Turns the Oscilloscope on and off.

   ILLUM — Adjusts graticule illumination.

2. "ON" LED — Lights when the POWER switch is turned clockwise from its OFF position.

3. INTENSITY — Clockwise rotation increases the brightness of the display. Adjust the brightness for your lighting conditions. Refocusing may be necessary when the intensity is changed. **CAUTION: Do not allow a bright spot to remain on the screen; it could damage the CRT.**

4. TRACE ROT — This is a seldom-used control that aligns the trace to the horizontal graticule lines. Readjustment may be required in the presence of magnetic materials, electromagnetic fields, or after moving the Oscillscope to a new location.

5. FOCUS — Varies the size of the electron beam striking the screen. Adjust for the sharpest display.

6. COMP TEST button — Enables or disables the component test operating mode.

7. COMP TEST jack — Used with the GND socket for testing various components.

8. GND — Provides a chassis ground that is connected to the 3-wire AC line cord (earth) ground.

9. CAL 2Vp-p — Provides a 1 kHz square wave signal useful for frequency compensation of probes, checking amplifier gain, etc.

10. BEAM FIND — Compresses sweep deflection to bring any off-screen trace to the center area of the screen as an aid in locating the trace.

Channel A (CHA) Controls

11. ▲▼POSITION — Positions the CHA trace vertically on the CRT screen. NOTE: This control is inoperative for the X-Y mode.

    PULL ALT TRIG — For dual trace signals, selects the triggering mode in which each sweep alternates between channel A (CHA) and channel B (CHB) signals as separate triggering sources.

12. 1 MΩ 25 pF — This BNC connector is the CHA input. It is also the X (horizontal) input during X-Y mode operation.

13. VOLTS/DIV — Each position of this attenuator switch is marked with a number that indicates the peak-to-peak input voltage required to produce a peak-to-peak deflection of one major division (1 cm) on the screen's graticule when the VAR PULL 5X MAG control is set to its CAL'D (fully clockwise) position and pushed in.

14. VAR PULL X5 MAG — This control is normally set to its CAL'D position (fully clockwise), where the VOLTS/DIV switch positions are calibrated. The vertical gain decreases as the control is turned counterclockwise, permitting the size of the vertical pattern to be adjusted in a continuous manner between the selected range and the next higher range. *

    When this knob is pulled out, the vertical amplifier sensitivity is increased by a factor of five. *

15. AC-GND-DC — This switch has three positions:

    AC: The input signal is capacitively coupled to the vertical amplifier and any DC component is blocked. The low-frequency limit is about 10 Hz (at –3 dB).

    GND: Disconnects (opens) the input circuit and grounds the vertical amplifier input. Use this position when you wish to set the trace to a desired reference baseline without disconnecting the input signal.

* The bandwidth is reduced when you use this control or switch.

DC: Both the DC and AC components of the input signal are applied to the vertical amplifier input.

Channel B (CHB) Controls

16. ▲▼POSITION — Positions the CHB trace vertically on the CRT screen. It is also the Y (vertical) position control in the X-Y mode.

    PULL INV — When the POSITION control is pulled out, the CHB trace (AC plus DC) is inverted.

17. 1 MΩ 25 pF — This BNC connector is the CHB input. It is also the Y (vertical) input during X-Y operation.

18. VOLTS/DIV — Each position of this attenuator switch is marked with a number that indicates the peak-to-peak input voltage required to produce a peak-to-peak deflection of one major division (1 cm) on the screen's graticule when the VAR PULL X5 MAG control is set to its CAL'D position (fully clockwise) and pushed in.

19. VAR PULL X5 MAG — This control is normally set to its CAL'D position (fully clockwise), where the VOLTS/DIV switch positions are calibrated. The vertical gain decreases as the control is turned counterclockwise, permitting the size of the vertical pattern to be adjusted in a continuous manner between the selected range and the next higher range. *

    When this knob is pulled out, the vertical amplifier sensitivity is increased by a factor of five. *

20. AC-GND-DC — This switch has three positions:

    AC: The input signal is capacitively coupled to the vertical amplifier and any DC component is blocked. The low-frequency limit is about 10 Hz (at –3 dB).

    GND: Disconnects (opens) the input circuit and grounds the vertical amplifier input. Use this position when you wish to set the trace to a desired reference baseline without disconnecting the input signal.

    DC: Both DC and AC components of the input signal are applied to the vertical amplifier input.

Both Channels Control

21. VERT MODE — This switch has four positions:

    CHA: Displays the Channel A trace only.

    CHB: Displays the Channel B trace only.

    DUAL: Displays both the CHA and CHB traces. The traces are normally alternating; that is, CHB is swept at the end of the CHA sweep and vice versa.

    You can select a chopping mode by pulling the HOLDOFF control. In this mode, the trace is quickly switched between the CHA and CHB inputs (at a 500 kHz rate) to enhance the viewing of signals with low sweep rates and to verify timing relationships between signals at low and medium sweep rates.

    ADD: With the PULL INV switch for CHB pushed in, displays the algebraic sum of the CHA and CHB signals (that is, CHA + CHB).

    With the PULL INV switch for CHB pulled out, displays the algebraic difference between the CHA and CHB signals (that is, CHA – CHB).

Triggering Controls

22. TRIG LEVEL — Adjust to select the starting point at which the sweep is triggered. Turn the control fully counterclockwise for a fixed (0 volts) level.

    PULL SLP (–) — When pushed in, the TRIG LEVEL adjustment covers the rising (positive) slope; when pulled out, it covers the falling (negative) slope.

23. COUPLING — Selects the triggering mode as follows:

    AUTO: For normal triggering. The sweep free-runs in the absence of a sufficient triggering signal.

    NORM: For normal triggering. No sweep occurs if the triggering signal does not meet the TRIG LEVEL amplitude and slope settings.

    TV-V: Rejects DC and high-frequency sync signals in a composite video signal.

    TV-H: Rejects DC and low-frequency sync signals in a composite video signal.

24. SOURCE — Selects the triggering source signal as follows:

    CHA: Channel A signal.

    CHB: Channel B signal.

    LINE: AC line-frequency.

    EXT: The signal applied to the EXT TRIG connector.

25. HOLDOFF — Use this control if the measured signal waveform is made up of complex repetitive cycles and the TRIG LEVEL control (22) alone is not sufficient to attain a stable waveform display.

    PULL CHOP — With this switch out, the Oscilloscope displays dual-trace signals by chopping (switching back and forth between traces) during the sweep – most useful at low sweep rates. With the switch in, the Oscilloscope alternates by showing the CHA trace on one sweep, and the CHB trace on another sweep – most useful at higher sweep rates.

26. EXT TRIG — Connect an external triggering signal to this connector. To use it, first set the SOURCE switch (24) to the EXT position.

Horizontal/Time Base Controls

27. ◄ ► POSITION — Positions the trace horizontally on the CRT screen. It is also the X (horizontal) position control in the X-Y mode.

    PULL X10 MAG — When the ◄ ► POSITION control is pulled out, the horizontal trace is expanded by a factor of ten.

28. TIME/DIV — Selects the time setting for the beam to sweep one major division (1 cm) on the CRT screen.

29. VAR — Provides a continuous adjustment of the sweep time between the selected range and the next slower range. The time base is calibrated with the knob set to its CAL'D position (fully clockwise).

X-Y Mode Controls

30. X-Y — With this switch pushed in, the SOURCE switch (24) set to CHA, and the VERT MODE switch (21) set to CHB, the instrument operates as an X-Y oscilloscope.

Rear Panel

31. Line Voltage and Fuse label — Lists the acceptable voltage range and fuse rating for each of the four ways that you can install the line voltage selector plug.

32. AC line voltage selector plug and fuse — Allows you to match your AC line voltage to the Oscilloscope's power transformer by aligning the arrowhead on the rear panel with the appropriate voltage (100, 125, 220, or 240) on the selector plug. The fuse is on the inside of the selector plug. CAUTION: For continued safety, replace the fuse with a properly rated part. Refer to the rear panel and the Parts List.

33. AC input socket — Receptacle for the 3-wire AC line cord.

34. Cord retainers — Used to store the line cord when the instrument is not in use. Also serve as feet when you operate the Oscilloscope in a vertical (stand-up) position.

* The bandwidth is reduced when you use this control or switch.

DMM OSCILLO SCOPE FRONT PANEL

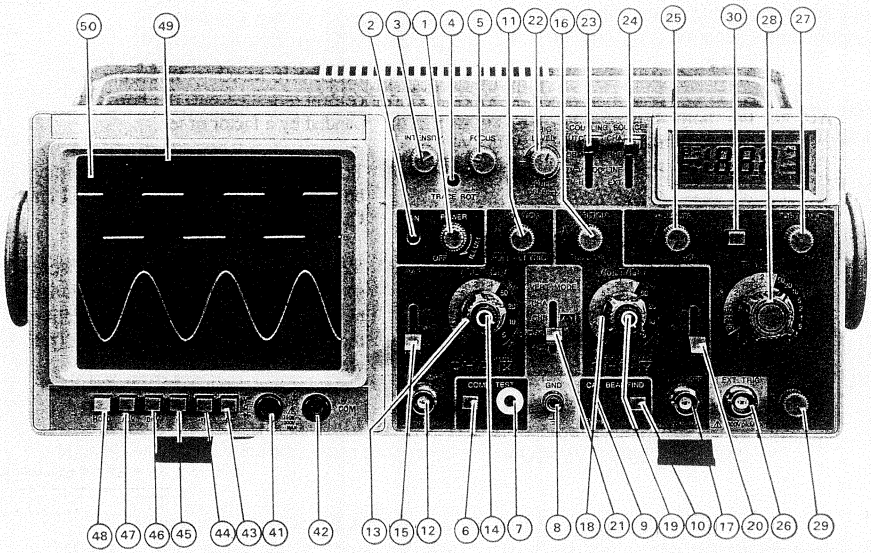


Figure 1A

DIGITAL MULTIMETER (DMM OSCILLOSCOPE ONLY)

41 — V. Ω. — Measuring Connector: To connect positive lead (red test lead) for voltage, resistance, diode, continuity measurement.

42 — "COM" — Measuring Connector: To connect negative lead (black test lead) for all kinds of measurements.

43 — Diode check.

44 — Continuity test.

45 — Ω — 0~20MΩ on 6 ranges.

46 — DCV — 0~1000V DC on 5 ranges.

47 — ACV — 0~750V AC on 4 ragnes.

48 — Hold — Press it once to hold the measured value.

PRELIMINARY OPERATION

1. Set the following controls to the indicated settings:

   POWER switch to OFF.

   INTENSITY control to midrange.

   VERT MODE switch to CHA.

   All three POSITION controls to midrange.

   Both AC-GND-DC switches to GND.

   TIME/DIV switch to .5 ms.

   VAR (sweep) control to CAL'D.

   COUPLING switch to AUTO.

   TRIG LEVEL switch pushed in (for + slope) and set fully counterclockwise.

   SOURCE switch to CHA.

   PULL X10 MAG switch pushed in.

   X-Y button out.

   Other controls may be in any position.

2. Check the LINE VOLTAGE SELECTOR setting on the rear panel to make sure it agrees with your AC line voltage.

3. Connect the AC line cord between the AC input socket and an AC outlet.

4. Set the POWER switch to ON. After about 20 seconds, a trace line will appear on the screen. Adjust the INTENSITY control to increase the brightness to suit your lighting conditions.

5. Adjust the FOCUS and INTENSITY controls for a well-defined, sharp trace line.

6. Readjust the vertical and horizontal POSITION controls to position the trace vertically centered and with the left end aligned at the left line of the graticule.

NOTE: Perform the following probe compensation steps for CHA and then, as directed, for CHB.

7. Set the VOLTS/DIV switch of CHA to 50 mV and the VAR control fully clockwise to CAL'D.

8. Set the AC-GND-DC switch for CHA to DC.

9. Connect a 10:1 probe to the input of CHA and hook the tip to the CAL 2Vp-p terminal. A square wave covering 4 divisions will be displayed.

10. If the square wave has excessive rounding or overshoot at the top corner, adjust the trimmer in the probe to produce the best flat top.

11. Remove the probe from the CAL terminal.

12. Set the VERT MODE and SOURCE switches to CHB. Then repeat steps 6 through 11 using a second probe for CHB.

NOTE: The foregoing procedure "matches" each probe to a particular channel. Interchanging probes requires the compensation procedure to be repeated.

The Oscilloscope is now ready for use.

TRIGGERING THE SWEEP

The horizontal (time base) circuitry can operate in two modes: AUTO and NORM. In the AUTO mode, triggering of the sweep occurs even in the absence of an input signal. In the NORM mode, a sweep occurs only when the input signal meets the conditions established by the triggering controls. The controls used for triggering are described in more detail below.

Oscilloscopes include circuits to display stable, triggered waveforms. Synchronization for the triggering is derived from the vertical input signal (or a time-related signal). It is important that triggering be synchronized to provide a waveform that is easy to view.

SOURCE (24) — Selects the source of the triggering signal as follows:

CHA: A signal sample derived from the CHA preamplifier is used as the triggering signal. NOTE: You must select this switch position when using the X-Y and ALT TRIG operation modes.

CHB: A signal sample derived from the CHB preamplifier is used as the triggering signal.

LINE: The AC line voltage frequency is used as the triggering signal.

EXT: The triggering signal is derived from the EXT TRIG connector. This provides three benefits, depending on operating conditions:

1. Triggering is not affected by variations of the vertical signals. For example, triggering normally changes with changes in the input signal amplitude or in the setting of the VOLTS/DIV switch. However, with a constant external trigger voltage, triggering is stable and not dependent on the vertical signal or control settings.

2. You can delay triggering the display of an input signal by using the output of a pulse generator that provides a pulse delayed from a triggering pulse.

3. With externally-provided synchronizing signals, a random or highly variable composite or modulated signal can be easily triggered.

COUPLING (23) — Selects the type of triggering as follows:

AUTO: A base line is automatically displayed even when no triggering signal is detected.

NORM: A trace appears only when the Oscilloscope's triggering signal meets or exceeds the trigger slope and level settings.

TV-V: The frequency range for the triggering signal is restricted to the bandwidth of 20 Hz to ~1000 Hz, provided the signal causes a deflection of at least 1 division on the CRT screen and the amplitude of an external triggering signal is within the –5 V to +5 V (TRIG LEVEL) range.

TV-H: The frequency range for the triggering signal is restricted to the bandwidth of ~1000 Hz to ~100 kHz, provided the signal causes a deflection of at least 1 division on the CRT screen and the amplitude of an external triggering signal is within the –5 V to +5 V (TRIG LEVEL) range.

TRIG LEVEL (22) — Adjusts the trigger circuits so the sweep can be started at any on-screen position of the input signal waveform. The sweep can be started on either a positive or negative slope, depending on whether the TRIG LEVEL control is in (+) or out (–).

PULL SLP (–) — This switch is part of the TRIG LEVEL control (22) and selects the trigger slope, positive or negative, of the trigger signal. For pulses, the switch selects the rising or falling edge.

HOLDOFF (25) — Adjusts the "pause" time between sweeps. This function is used when the time base triggering is unstable in viewing repetitive, complex, waveforms. The hold-off time is continuously variable from no delay (MIN) to 5 times the total normal sweep time on every range from .1 µs/DIV to .2 s/DIV. Adjust it as required to delay retriggering the sweep.

EXT TRIG (26) — An external signal applied through this connector triggers the sweep circuits in accordance with the trigger slope and level settings.

PULL ALT TRIG (11) — For the dual-trace mode, with this switch out and the SOURCE switch set to CHA, the CHA signal is used to trigger just the CHA sweep while the CHB signal triggers just the CHB sweep. This enhances the display stability of independent (asynchronous) waveforms, such as from signals having different repetition rates.

NORMAL OPERATING CHARACTERISTICS

The following information is provided to help answer possible questions that you may have about the operation of your Oscilloscope.

- It may require two or three minutes for the trace to stabilize when you first turn on the Oscilloscope, especially on the more sensitive voltage ranges. A short warm-up period (about 5 minutes) is recommended before you make sensitive measurements.

- When you use the PULL INV switch, the display of a symmetrical, repetitive signal may not appear to be inverted, but it actually is.

- In the AUTO position, with no input signal, the trace may blink. This is due to random triggering due to noise detected by the sensitive vertical circuits.

- Random noise on the input signal may cause false triggering, especially on the most sensitive voltage ranges when the TRIG LEVEL control is near its fully CCW (counterclockwise) position.

USING A 1-MILLIVOLT OSCILLOSCOPE

When you use an oscilloscope as sensitive as this one, you must use special care to make reliable low-level measurements. Keep the following points in mind when you measure very low level signals.

- Placement of the ground clip may be critical if the signal ground circuitry carries appreciable current. Voltage differences of several millivolts are common from one side of a chassis or ground foil to another. Attach the ground clip to a point nearest the signal source. This usually gives the smallest error. You may have to move the ground clip when you measure at different points.

- It may be difficult to eliminate the pickup of stray 60 Hz signals, especially in high-impedance circuits. Be sure to use shielded test cables. If necessary, shield the signal source.

- Wideband measurements in the millivolt and microvolt regions are more difficult because of the inherent noise (shot noise and thermal noise) generated by electronic components. This may cause the baseline to appear wider or out of focus. Noise that appears as "hash" or "spikes" on the baseline may be caused by electromagnetic pickup of external "noise generators" such as lightning, automotive ignition, appliances, etc. Noise of any kind may cause erratic triggering.

- Radio frequency interference may be picked up in strong RF signal areas. This type of interference may come from a commercial broadcasting station or from nearby RF equipment.

- Thermal drift may also result if the test clip is connected across a junction of two dissimilar metals or across a semiconductor. This will appear as a baseline drift when the junction temperature changes.

OPERATING EXAMPLES

This section of the Manual gives several examples of how to use the Oscilloscope in its different modes of operation. These examples will help you become familiar with the controls, especially the sweep and triggering controls, and with dual-trace operation.

Example 1 — Triggering the Sweep on the + or – Slope of a Waveform

Signal source: Sine wave generator of approximately 1 kHz.

1. Set the switches as follows:

AC-GND-DC (CHA):	AC
VERT MODE:	CHA
COUPLING:	AUTO
SOURCE:	CHA
TIME/DIV:	.5 ms
TRIG LEVEL:	Fully CCW
▲▼POSITION (CHA):	Centered trace

2. Connect the 1 kHz sine wave signal to the CHA input connector. Adjust the VOLTS/DIV switch or source level to provide a display that is 6 cm peak-to-peak.

3. Refer to Figure 3 and adjust the TRIG LEVEL control. Notice how the trigger starting point changes. When you turn the control fully clockwise, the trace will blank out momentarily and then begin to move (not locked in).

4. Set the TRIG LEVEL control for a stable display.

5. Pull the TRIG LEVEL control out. The waveform should now trigger on the – slope and appear inverted.

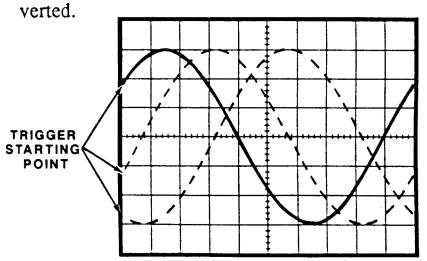


Figure 3

Example 2 — Normal or Automatic Triggering of the Signal Source

The AUTO (automatic triggering) mode provides a baseline or reference trace even without a vertical input signal. This automatically-triggered trace line is used as a voltage reference point with the channel's AC-GND-DC switch at GND, especially for DC measurements.

1. Change the TIME/DIV switch setting to 1 ms. The waveform should show approximately 10 complete cycles.
2. Set the COUPLING switch to NORM. There should be no change in the display. The Oscilloscope is now in the normal triggering mode.
3. Set the AC-GND-DC switch for CHA to GND. There should be no display. With the COUPLING switch in the NORM position, a baseline is not generated when the input signal is lost.
4. Set the COUPLING switch to AUTO. The automatic baseline will appear.
5. Set the AC-GND-DC switch for CHA to AC. The display should reappear.
6. Set the COUPLING switch to NORM. There should be no change in the display.
7. Turn the TRIG LEVEL control knob fully clockwise and notice that there is no trace.
8. Set the COUPLING switch to AUTO. The display will reappear but will not be stabilized.
9. Set the TRIG LEVEL control for a stable sine wave display that starts on its left end at 1 full division (1cm) above the horizontal center line.

Example 3 — Dual-Trace Operation

1. Connect a 1 kHz sine wave to both the CHA and CHB input connectors. NOTE: Be sure that both VOLTS/DIV switch settings are the same.
2. Set the VERT MODE switch to DUAL.
3. Set the AC-GND-DC switch for CHA and CHB to AC.
4. Set the SOURCE switch to CHA.
5. Set the COUPLING switch to AUTO.
6. Set the TIME/DIV switch to .2 ms.
7. Set the signal generator for a display that is approximately 4 divisions (4 cm) high and set the TRIG LEVEL control for a stable display.
8. Adjust the ▲▼ POSITION controls for CHA and CHB so that the waveforms are separated, as shown in Figure 4. NOTE: You can turn off either channel by setting the AC-GND-DC switch to GND or the VERT MODE switch to CHA or CHB. However, when CHB is selected (CHA is off), you will also lose triggering.

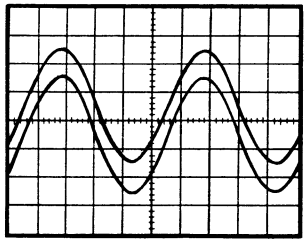


Figure 4

Example 4 — Pull to Invert Switch

1. Connect a 1 kHz sine wave signal to both the CHA and CHB input connectors. Select VOLTS/DIV settings that provide a 1 to 2 cm peak-to-peak display for each input. NOTE: Be sure that both VOLTS/DIV switch settings are the same.
2. Set the VERT MODE switch to DUAL.
3. Set both AC-GND-DC switches to AC.
4. Set the SOURCE switch to CHA.
5. Set the COUPLING switch to AUTO.
6. Set the TIME/DIV switch to .5 ms.
7. Be sure the PULL INV switch (part of the POSITION control for CHB) is pushed in to its normal position. The CHB display should be identical to the CHA display.
8. Set the VERT MODE switch to ADD. Now the signal is twice as high as either the CHA or CHB signal. This is the algebraic summation of the two waveforms.
9. Pull the PULL INV switch out. Now the display is nearly a straight line. The Oscilloscope is subtracting the CHB waveform from the CHA waveform and the result is zero.

NOTE: Due to aging of components and adjustments, the calibration may have changed slightly. Adjust whichever VAR control is required to reduce the trace to a straight line, if necessary.

This function is useful in making differential measurements. For example, if the CHA and CHB inputs are connected across a low-value resistor, the differential measurement voltage across the resistor reflects the current passing through it as long as the absolute value of each input signal provides a nearly on-screen trace.

Adjust the VAR control for either CHA or CHB and notice how the display changes. This makes the gains of the channels unequal; therefore, the difference does not result in zero.

NOTE: It may be impossible to get a zero result (flat trace) when making a differential measurement (even at the same test point) at high frequencies or for fast rise time signals due to slight differences in the response of the two channels. This is a natural characteristic of any oscilloscope.

APPLICATIONS

VOLTAGE MEASUREMENTS

NOTES:

1. Reference to the VOLTS/DIV switch, AC-GND-DC switch, and VAR control in this section apply to CHA or CHB, except as noted.

2. When you use a 10:1 probe, the waveform display is only 1/10 of the actual voltage being measured. Therefore, be sure to multiply all VOLTS/DIV settings by 10.

3. When the PULL X5 MAG switch is out, divide each VOLTS/DIV setting by 5; that is, 5 mV/division becomes 1 mV/division.

You can use either the CHA or CHB input of the Oscilloscope as a voltmeter to measure peak, peak-to-peak, DC voltages, or a specific portion of a complex waveform.

1. Set the COUPLING switch to AUTO.

2. Turn the VAR control (on the VOLTS/DIV switch) fully clockwise to the CAL'D position.

3. Set the VOLTS/DIV switch for the trace amplitude to be used.

4. Temporarily set the AC-GND-DC switch to GND and adjust the ▲▼POSITION control to set the trace to a reference level.

5. For DC or complex signals, set the AC-GND-DC switch to DC. For CHB signals, be sure the PULL INV switch is pushed in.

6. A positive voltage will deflect the trace upward from the reference level, and a negative voltage will deflect it downward. To determine the voltage, multiply the vertical deflection (in divisions) by the setting of the VOLTS/DIV switch (taking into account the possible use of a 10:1 probe and the X5 multiplier function).

Peak-to-Peak Voltage Measurements

To measure the peak-to-peak voltage of a signal:

1. Adjust the ▲▼POSITION control to set the bottom of the waveform on one of the horizontal grid lines.

2. Multiply the peak-to-peak vertical deflection (in divisions) by the setting of the VOLTS/DIV switch.

Example:

As shown in Figure 5, the display amplitude is 4 divisions. If the VOLTS/DIV switch is set at .2 V, then:

Peak-to-Peak Voltage = 4 div. x .2 volts/div.
= .8 volts.

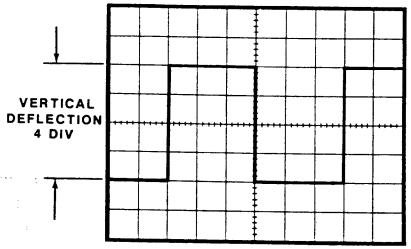


Figure 5

Instantaneous Voltage Measurements

To measure the voltage at any point on a waveform with respect to ground:

1. Set the AC-GND-DC switch to GND and adjust the trace to some reference line.

2. Set the AC-GND-DC switch to DC. For CHB signals, be sure the PULL INV switch knob is pushed in. If the waveform is above the reference line, the voltage is positive. If the waveform is below the reference line, the voltage is negative.

3. Measure the vertical difference (in divisions) between the reference line and the desired point on the waveform, and multiply it by the VOLTS/DIV switch setting.

Example:

As shown in Figure 6, the vertical difference is 3 divisions and the VOLTS/DIV switch is set at 50 mV. The indicated voltage step is:

3 div. x 50 mV/div. = 150 mV above the reference line (ground).

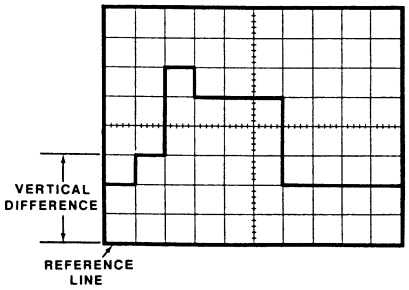


Figure 6

TIME DURATION AND FREQUENCY MEASUREMENTS

To find the time duration between two points on a waveform, multiply the horizontal distance (in divisions) between the two points by the setting of the TIME/DIV switch. Frequency is the reciprocal of the time duration of one cycle of a repetitive signal.

Example:

As shown in Figure 7, the horizontal distance measured is 8.3 divisions. The TIME/DIV switch is set to 2 ms. Therefore:.

Time Duration = 8.3 div. x 2 ms/div.
= 16.6 ms.

and

Frequency = 1/(time duration)
= 1/16.6 ms
= 60 Hz.

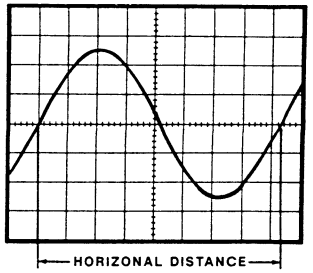


Figure 7

RISE TIME MEASUREMENTS

Rise and fall time measurements are made the same way as time duration measurements, except these measurements are made between the 10% and 90% points of the waveform's overall amplitude.

To measure rise time:

1. Set the peak-to-peak (or zero-to-peak) amplitude to exactly 5 divisions by adjusting the input signal and/or the VOLTS/DIV switch (provides maximum bandwidth) or by adjusting the VAR control (results in reduced bandwidth).

2. Adjust the ▲▼POSITION control and waveform amplitude so that the display bottom just touches the 0% graticule line and the display top just touches the 100% graticule line. See Figure 8.

3. Select the desired slope ("+" for rise time, "–" for fall time) and adjust the TRIG LEVEL control for a full-height display at the trigger point (left end of the trace).

4. Change the TIME/DIV switch setting to a range where the rising or falling edge extends over several horizontal divisions. You may need to turn up the INTENSITY control to make the trace brighter. Adjust the TRIG LEVEL control to display the lower portion of the waveform edge, if necessary. For the fastest sweep settings, the portion of the rising edge below the 10% level may not be visible.

5. Adjust the horizontal position control so you can measure the horizontal distance between the 10% and 90% points (4 divisions) on the waveform.

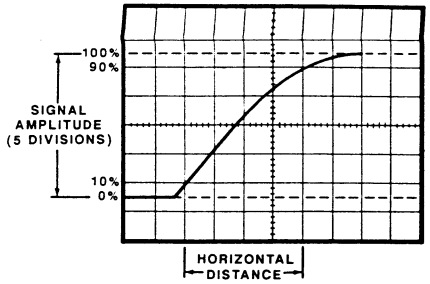


Figure 8

6. Rise time is the horizontal distance between the 10% and 90% points times the TIME/DIV setting. Fall time is similarly measured on the falling transition of the waveform.

Example:

The horizontal distance between the 10% and 90% points on the waveform is 4 divisions and the TIME/DIV switch is set at 1 µs.

Rise Time = 4 div. x 1 µs/div.
= 4 µs.

NOTE: When measuring very fast rise times (less than 35 ns), the VAR control must be in its CAL'D position. This guarantees full bandwidth and a minimum Oscilloscope rise time. With fixed VOLTS/DIV and VAR settings, you may have to carefully measure the 10% to 90% points if the waveform amplitude cannot be externally set to 5 divisions peak-to-peak. The Oscilloscope's fixed rise time (t_r scope) extends the displayed rise time (t_r display) in combination with the unknown rise time. The unknown rise time is computed from :

$$(t_r \text{ display})^2 = (t_r \text{ scope})^2 + (t_r \text{ unknown})^2$$

so:

$$t_r \text{ unknown} = \sqrt{(t_r \text{ display})^2 - (t_r \text{ scope})^2}$$

The scope's rise time is typically 18 ns @ 5 divisions.

EXPANDING THE WAVEFORM

If you need to expand a certain portion of the displayed waveform, you may use a faster sweep. However, if the desired portion is far away from the starting point of the sweep, the desired portion may run off the CRT screen. If it does, select a slower sweep speed and pull the PULL X10 MAG switch out. The displayed waveform will then be expanded by 10 times to the right and left, with the center of the screen at the center of the expansion.

You can determine the sweep time for the magnification process by multiplying the TIME/DIV switch setting by 1/10.

Example (see Figure 9):

The TIME/DIV switch setting for a square wave is .2 µs/division. Therefore, this unmagnified maximum sweep speed can be made faster with magnification as follows:

Magnified Sweep Speed = .2 µs/div x 1/10
= 20 ns/div.

NOTE: When the sweep is magnified as the result of a faster sweep speed, the trace may become faint.

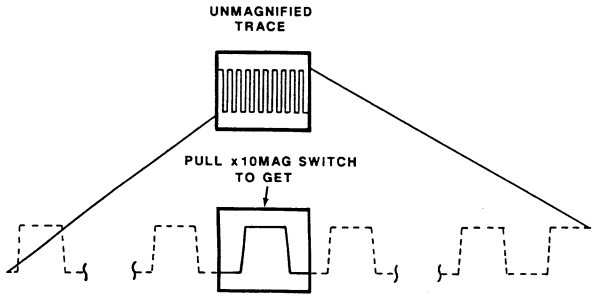
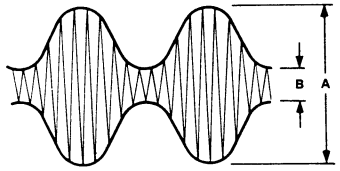


Figure 9

AM MODULATION MEASUREMENT

There are many methods of measuring AM modulation, but here the envelope method is shown. This method is applicable only if the carrier frequency is within the bandwidth of this instrument. Figure 10 shows the display of a modulated wave. Measure the peak-to-peak values at "A" and "B" to compute modulation.



$$\text{MODULATION \%} = \frac{A-B}{A+B} \times 100$$

Figure 10

DUAL-TRACE APPLICATIONS

Differential Measurements

1. Make sure the CHA and CHB AC-GND-DC and VOLTS/DIV switches are in the same positions.

2. Set the VERT MODE switch to ADD.

3. Pull the PULL INV switch for CHB out. The resulting display is now CHA – CHB. Determine the difference in amplitude directly by multiplying the vertical height (in divisions) by the setting of either VOLTS/DIV switch. NOTE: Both ▲▼ POSITION controls move the trace.

Phase Angle Measurements

The dual-trace method of measuring the phase difference between two signals of the same frequency is more accurate and easier to use than the X-Y (Lissajous) method. It can also be used up to the full frequency limit of the vertical system. To make a measurement:

1. Set the VERT MODE switch to DUAL, and use the ▲▼ POSITION controls to position both automatic baseline traces on the center line of the graticule. For low-frequency signals, pull the HOLDOFF switch out to select the CHOP mode.

2. Connect the reference signal to the CHA input connector and the signal for comparison to the CHB input connector. Use coaxial cables (with probes) that have equal time delay (or physical length for the same type of cable).

3. Set the CHA and CHB VOLTS/DIV switches and input signal levels so that both displays are about 4 divisions high.

4. Set the TIME/DIV switch to a sweep rate that displays one cycle of the reference waveform.

5. Turn the ◄ ► POSITION and VAR (sweep) controls until one cycle of the reference signal occupies exactly 8 divisions between the first and ninth graticule lines. Each horizontal division of the graticule now represents 45°. Use the horizontal separation between zero crossings (or peaks) to measure the phase angle.

Example:

The horizontal difference is 1.0 division, as shown in Figure 11. Therefore:

Phase Difference = 1.0 div. x 45°/div.
= 45°.

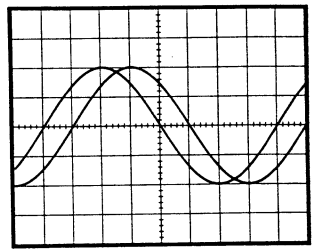


Figure 11

Comparison of Levels (Gain/Loss)

An example of interconnections for the output/input level comparisons of an amplifier is shown in Figure 12.

Superimpose the displays of CHA and CHB using the ▲▼ POSITION controls. The gain in the amplifier will be the difference in the calibrated settings of the respective VOLTS/DIV switches for matched CHA and CHB waveforms.

When adjustment of the VAR control of one channel cannot exactly superimpose the traces, the difference is due to distortion or phase shift in the amplifier. Set the VERT MODE selector to ADD and pull the PULL INV switch to view only the output distortion. The trace will be a straight line when distortion is absent.

For example, stereo audio systems have two symmetrical amplifier circuits. Using the dual trace feature, you can compare and check the operation at corresponding points in each circuit. This makes it easier to locate a problem in one channel.

Triggering from Asynchronous Input Signals

One of the features of your Oscilloscope is the ALT TRIG function in which, for dual trace signals, triggering of each sweep can be set to alternate between CHA and CHB as separate sources. This provides a stable display of any two signals, even if they are independent and not frequency related (asynchronous).

To select the alternating trigger mode, set the VERT MODE switch to DUAL, the COUPLING switch to CHA, and pull the CHA POSITION control out. The sweep will then be triggered by the CHA and CHB signals alternately.

SERVICING TV SETS

For this application, a triggered oscilloscope is indispensable. This instrument can synchronize to either the TV-V (Frame) or TV-H (Line) of the video signal to display the blanking pedestal, VITS/VIRS *, or vertical/horizontal synchronizing pulses.

The most important waveforms used for TV servicing are the composite signals consisting of the video, blanking pedestal, and sync pulses provided at the video (detector) output. Figure 13 shows composite signals synchronized using horizontal "sync" pulses. Figure 14 shows composite signals synchronized using vertical "sync" pulses.

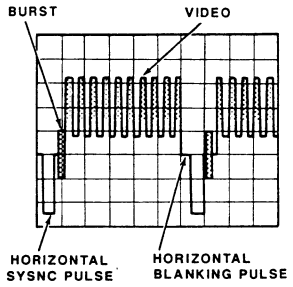


Figure 13

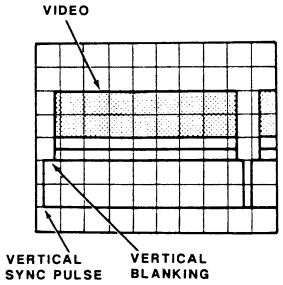


Figure 14

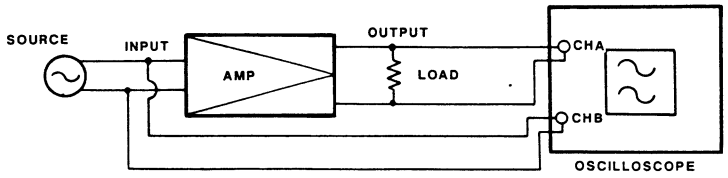


Figure 12

* Vertical Interval Test Signals/Vertical Interval Reference Signals

X-Y MODE OPERATION

With the X-Y switch pushed in, the SOURCE switch set to CHA, and the VERT MODE switch set to CHB, the instrument will operate as an X-Y oscilloscope.

CHA signals produce a horizontal deflection (X) while CHB signals produce a vertical deflection (Y). The CHB ▲▼ POSITION control adjusts the vertical (Y) position, and the ◄ ► POSITION control adjusts the horizontal (X) position. The AC-GND-DC and VOLTS/DIV switches for CHA and CHB and the PULL INV switch for CHB operate as previously described.

Using the X-Y mode will produce trapezoidal waveforms for evaluating AM modulation (X is the modulating signal and Y is the modulated output) and Lissajous waveforms for evaluating frequency and phase relationships of two signals. You can also use this mode to connect the Oscilloscope as the voltage-versus-current display for a semiconductor curve tracer. Refer to the curve tracer Manual for instructions.

Frequency Measurements

Set the X-Y, SOURCE, and VERT MODE switches for X-Y operation as explained above. Then connect a standard frequency signal to the CHA input connector and the unknown signal to the CHB input connector. The display will be a Lissajous figure, examples of which are shown in Figure 15.

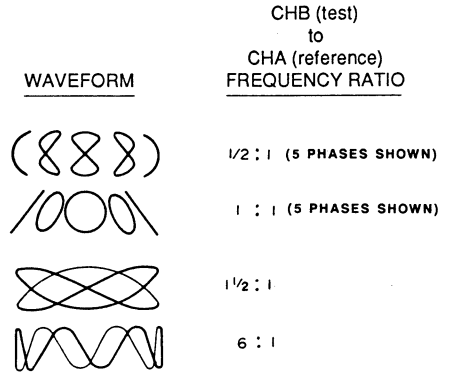


Figure 15

TRIGGERING AN APERIODIC SIGNAL

A typical low-duty cycle, repetitive, complex waveform is shown in Figure 16. Viewed with normal triggering, the various portions of the waveform overlap on the screen, making signal observation very difficult. In Part A, there is no hold-off time delay between the sweeps, and the sweep waveform is triggered at the first available rising transition after each sweep is completed.

In Part B, the waveform displayed on the screen is shown without the confusing overlap because triggering of the signal is held off as required by turning the HOLDOFF control. In such a case, you can easily synchronize the sweep repetition rate to the measured signal waveform rate by adjusting the "pause" time between sweeps.

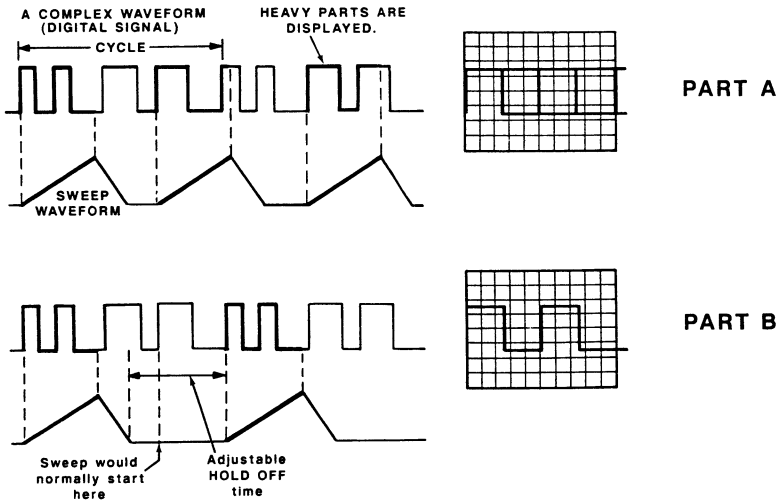


Figure 16

USING THE COMPONENT TESTER

NOTE: Before you can test components with your Oscilloscope, you will need a pair of test leads. A black lead and a red lead, each about 24" long, with banana plugs at one end and mini-clips at the other, will serve the purpose well. See Figure 17.

1. Press the COMP TEST button (6) to place the Oscilloscope in the component test mode.

2. Readjust the INTENSITY control to the preferred level. Then set the FOCUS control for a well-defined, sharp trace.

3. Set the ◄ ► POSITION control to center the trace.

4. Connect the red test lead to the COMP TEST jack (7) and the black test lead to the GND jack (8).

NOTE: We recommend that you make "out-of-circuit" measurements. If you are making "in-circuit" measurements, be sure you first turn off power to the unit.

5. Connect the clips of the test leads to the device to be tested.

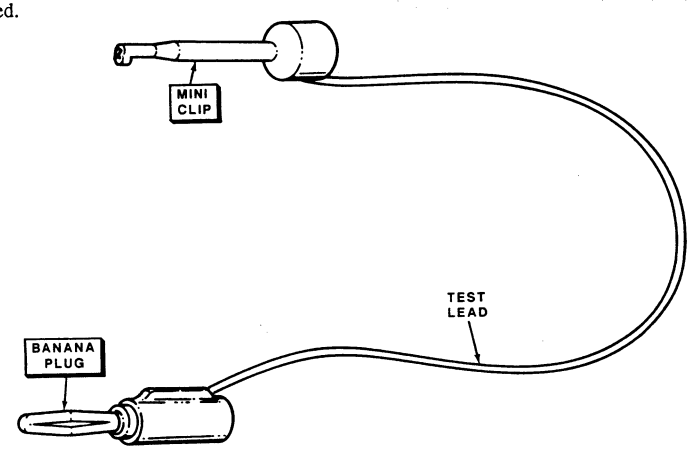


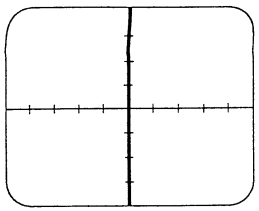
Figure 17

NOTE: The Waveform Chart on Page 25 shows some typical curves for different devices. To determine the condition of a part, it may be necessary to test a known good device first and compare its curve with that of a device that you suspect may be faulty.

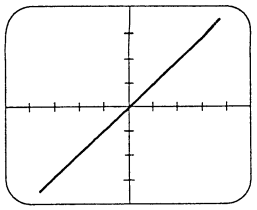
CAUTION: Transistors used in high-gain, low-noise applications may be permanently degraded when subjected to a base-emitter reverse voltage that exceeds their breakdown rating. The COMP TEST open-circuit test voltage can be as high as 9 volts peak. This voltage can be reduced by resistive loading or a zener "clamping" diode to permit safe (non-damaging) transistor testing (see the next to the last illustration). Consult the vendor specifications for the device being tested or use low-voltage junction testing (with an ohmmeter) if you are in doubt.

6. After you have completed the component testing, push the COMP TEST button to release it. This returns the Oscilloscope to normal operation and disconnects the COMP TEST jack.

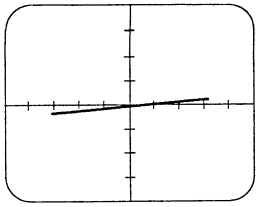
WAVEFORM CHART



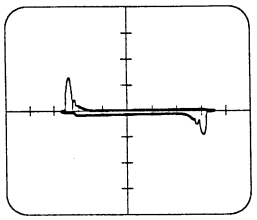
0 Ω (short)



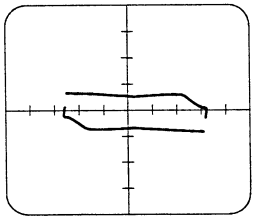
500 Ω resistor



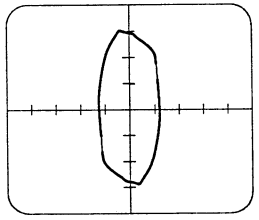
10 kΩ resistor



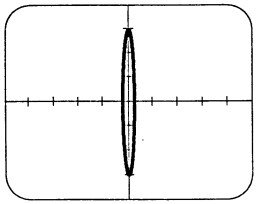
.1 µF ceramic capacitor



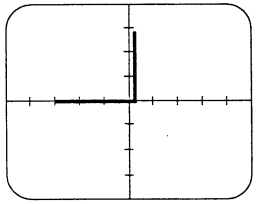
1 µF electrolytic capacitor



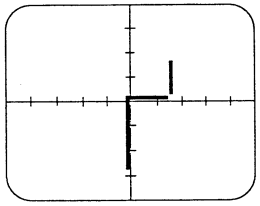
10 µF electrolytic capacitor



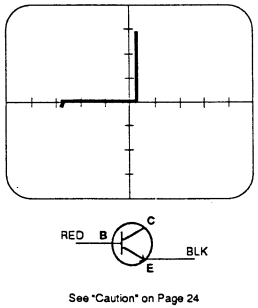
100 µF electrolytic capacitor



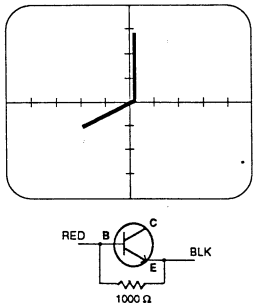
Silicon diode



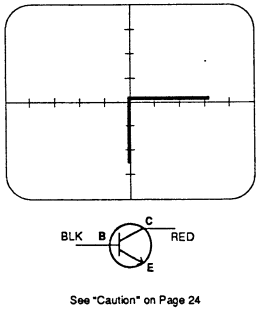
4.7 V zener diode



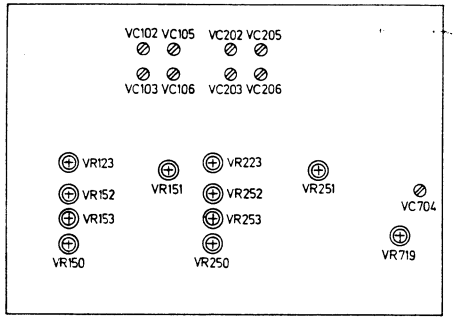
See "Caution" on Page 24



1000 Ω



See "Caution" on Page 24



(NOTE: All controls are accessed on the foil side.)

Figure 18

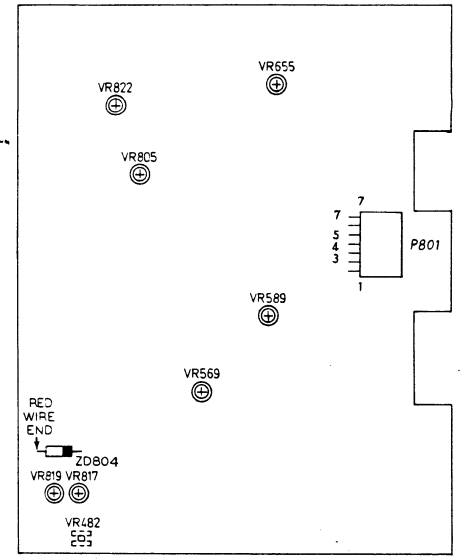
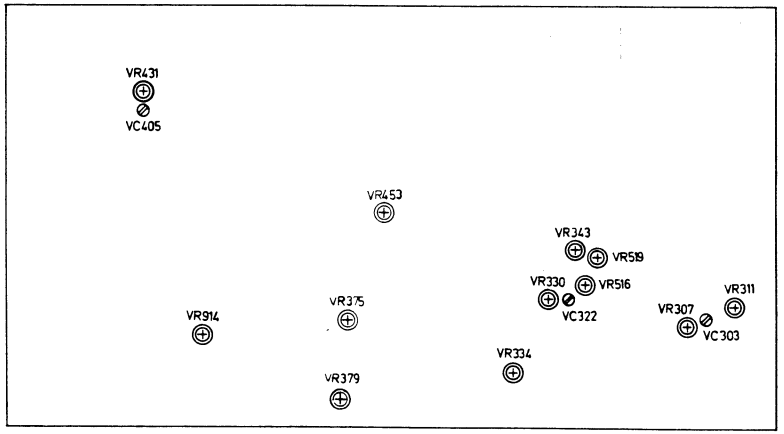


Figure 19



(NOTE: All controls are accessed on the foil side.)

Figure 20

MAINTENANCE AND ADJUSTMENTS

GENERAL MAINTENANCE

Preventive Maintenance — Clean and recalibrate the Oscilloscope on a regular basis to keep the instrument looking nice and working well.

Cleaning — Remove any dirt, dust, and grime whenever they become noticeable. You can remove dirt from the outside covers with a soft cloth moistened with a mild cleaning solution.

Recalibration — Recalibrate the Oscilloscope after 1000 hours of operation or twice a year if used daily.

Servicing — If the Oscilloscope ever becomes inoperative or damaged, refer servicing to a qualified repair facility. Repair and calibration service is available from the Heath Company.

ADJUSTMENTS AND CALIBRATION

CAUTION: Be careful when calibrating your Oscilloscope; dangerous high voltage exists in several areas.

You will need the following test equipment when calibrating your Oscilloscope:

- DC voltmeter (or DMM) for measuring ±2 V to ±200 V with ±0.25% accuracy.
- High-voltage DC meter or probe for measuring – 2100 VDC with ±0.5% accuracy.
- Precision calibrator (±0.25% accuracy) providing 1 µs to 1 ms timing signals.
- 50 Ω, 1 MHz, square wave/pulse source with rise time of 1 ns or less.
- High-quality square wave signal source at 1 kHz and 10 kHz with precision amplitude of 50 mV peak-to-peak (±0.5% accuracy) and optional amplitudes of .1, 1, and 10 V peak-to-peak.
- Sine wave source at 1 kHz and 10 kHz.
- Low-range capacitance meter for measurement of approximately 25 pF, if a source that provides high-quality square wave amplitudes of .1, 1, and 10 V peak-to-peak is not available.

1. With the line cord disconnected, remove the cabinet top and bottom.
2. Preset the front panel controls as described in steps 1 through 4 under "Preliminary Operation" on Page 12.
3. Allow the Oscilloscope at least a 20-minute warm-up time before you start the calibration.

NOTES:

1. Use an insulated, low-capacitance adjustment tool for all of the following adjustments.
2. Measure each voltage with respect to a convenient ground (chassis) point.
3. Refer to Figures 18, 19, and 20 for the location of the controls called out in the following steps.

Power Supply Adjustment

1. +12 V adjustment — Adjust VR914 for +12 ±0.05 V at pin 4 of connector P801. Adjust this voltage very carefully, as it provides a reference for the other supplies.
2. –12 V check — Check pin 5 on connector P801 for –12 ±0.2 V.
3. +5 V check — Check pin 3 on connector P801 for +5 ±0.25 V.
4. +145 V check — Check pin 7 on connector P801 for +145 ±5 V.

CAUTION: During the following measurement, use a high input impedance voltmeter and a probe that are rated for high-voltage measurements (–2100 VDC). Use **extreme care.**

5. –2 kV check — Check the anode (unbanded) end of ZD804 (at red wire) for –2050 ±50 V.

CRT Circuit Adjustments

1. Minimum Intensity — Turn the front panel INTENSITY control to the 9 o'clock position. Then adjust VR819 so that the trace line is just dimly visible.
2. Maximum Intensity — Turn the front panel INTENSITY control fully clockwise. Then adjust VR817 so that the thickness of the trace line is no more than 2/3 of one minor division of the vertical graduation at sharp focus.
3. Astigmatism — Set the VERT MODE switch to CHB, push the X-Y switch in, and use the ◄ ► POSITION and CHB controls to place the beam spot in the center of the CRT screen. Then adjust VR822 in combination with the front panel FOCUS control so that the shape of the displayed beam spot becomes as sharp and nearly circular as posssible. Push the X-Y button to its normal (out) position and set the VERT MODE switch to CHA.
4. Trace Rotation — Adjust the front panel TRACE ROT control until the trace is parallel with the horizontal graticule lines.
5. Blanking — Set the TIME/DIV switch to to .1 ms,. and apply a 10 kHz sine wave signal to the CHA input connector. Adjust the TRIG LEVEL control for a stable waveform. Then adjust VR805 to make any "retrace" line (from right to left on the CRT screen) disappear. Then check each position of the TIME/DIV switch to make sure the retrace is not visible with a viewable sweep. Readjust VR805, if required.

Vertical Amplifier Adjustments

NOTE: Perform the following sequence of adjustments (steps 1 to 8) for CHA and then repeat for CHB. Adjustments specific to only one channel are indicated.

1. Step DC balance — Set the AC-GND-DC switch to GND. If the trace line shifts vertically when you switch between the most sensitive positions of the VOLTS/DIV switch, adjust VR123 (CHA) or VR223 (CHB) to obtain minimum shift.
2. X5 MAG DC balance — If the trace line shifts vertically when you pull the VAR switch for X5 magnification, adjust VR152 (CHA) or VR252 (CHB) for minimum shift between the out and in position of the VAR switch. After completing the adjustment, push the switch in..
3. Variable DC balance — If the trace line shifts when you turn the VAR control from the CAL'D position, adjust VR153 (CHA) or VR253 (CHB) for minimum shift. After completing the adjustment, leave the control at the CAL'D position.
4. ADD mode DC balance — Perform the following steps:
   A. Set the VERT MODE switch to CHA. Then, using the CHA ▲▼ POSITION control, move the trace to the center of the screen.
   B. Set the VERT MODE switch to CHB. Then, using the CHB ▲▼ POSITION control, move the trace to the center of the screen.
   C. Set the VERT MODE switch to ADD, and adjust VR343 to position the trace at the center of the screen. Then set the VERT MODE switch to CHA.
5. Sensitivity calibration — For this adjustment, you will need a square wave generator that produces a 1 kHz signal with a 50 mV peak-to-peak precision output amplitude. Perform the following steps:
   A. Set the TIME/DIV switch to 1 ms.
   B. Set the generator for a 50 mV p-p square wave output and connect it to the CHA or CHB input terminal, as required.
   C. Set the AC-GND-DC switch to DC.
   D. Be sure the VAR control on the VOLTS/DIV switch is set to the CAL'D position and set the VOLTS/DIV switch to 10 mV.
   E. Adjust VR334 (CHA) or VR311 (CHB) for exactly 5 divisions of amplitude.

NOTE: After you complete this adjustment, the other VOLTS/DIV positions should be calibrated to their specified accuracy (±3%, typical).

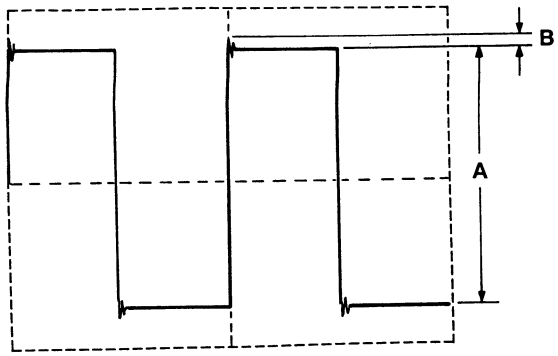


Figure 21

6. X5 gain calibration — Perform the following steps:

   A. Set the square wave generator for a 10 mV output and connect it to the CHA or CHB input terminal, as required.

   B. Be sure the VAR control is set to the CAL'D position and pull the knob out for X5 MAG.

   C. Adjust VR150 (CHA) or VR250 (CHB) for exactly 5 divisions of amplitude.

   D. Push both VAR knobs in.

8. Vertical transient response — For this adjustment, you will need a high-quality 50 Ω terminated, 1 MHz, square wave or pulse signal with a rise time of 1.0 ns or less.

   Perform the following steps:

   A. Set the VOLTS/DIV switch to 10 mV and the TIME/DIV switch to .2 us.

   B. Apply a square wave signal of 1 MHz to the CHA input connector through a terminated 50 Ω cable with BNC connector and adjust the level for 6 divisions of amplitude.

   C. Adjust VR431, VC405, VR330, VC322, and VR151 until you obtain a waveform like the one shown in Figure 21. The following condition must be met: (B/A) x 100% ≤ 5%.

      Since there is some interaction between the control and capacitor settings, be patient and take your time as you reduce the B amplitude.

   D. Apply the 1 MHz square wave signal to the CHB input connector and adjust the level for 6 divisions of amplitude.

   E. Adjust VR307, VC303, and VR251 until you obtain a waveform as outlined in step C. **Do not** adjust VR431 and VC405 this time.

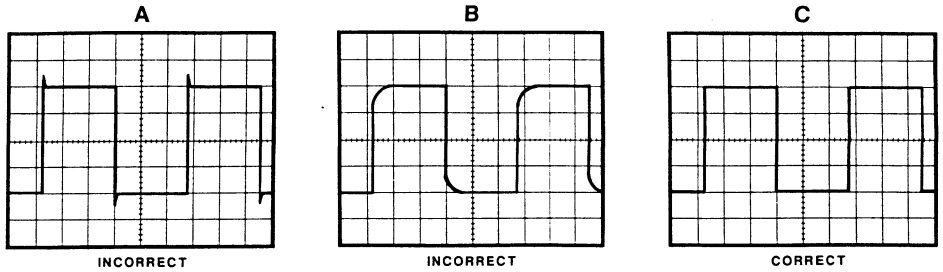


Figure 22

Input Attenuator Adjustments

NOTE: Perform the following sequence of adjustments (steps 1 and 2) for CHA and then repeat for CHB.

1. The purpose of the following adjustments is to obtain the proper amount of high-frequency compensation for all positions of the VOLTS/DIV switch. Figure 22 shows the conditions of too much compensation (A), too little compensation (B), and the correct amount of compensation (C).

   NOTE: You will need a square wave generator that delivers a high-quality 1 kHz to 10 kHz signal with a rise time of 1 µs or less and without sag or overshoot.

   Perform the following step:

   Apply the signal to the appropriate CHA or CHB input connector. Set the VOLTS/DIV switch first to the .1 position and then to the 1 position, and display a waveform with an amplitude of 4 to 6 divisions over 2 to 5 cycles while you make the following adjustments to obtain a correct compensation waveform display:

RANGE	ADJUST CAPACITOR
.1 V	VC103 (CHA) or VC203 (CHB)
1 V	VC106 (CHA) or VC206 (CHB)

2. The purpose of the following adjustments is to set the input capacitance of CHA and CHB equal for all VOLTS/DIV switch positions. With equal input capacitances in all positions, a 10:1 probe needs to be adjusted only once for proper high-frequency compensation.

   Two methods of adjustments are provided. Method 1 requires the use of a 10:1 probe and a high-quality square wave signal at approximately .1, 1, and 10 volts peak-to-peak. Method 2 requires a low-range capacitance meter for measurement of approximately 25 pF.

Method 1

A. Connect the 10:1 probe to the appropriate CHA or CHB input connector. Set the VOLTS/DIV switch to 20 mV. Then adjust the trace position, TIME/DIV switch setting, and triggering for a display as shown in "C" of Figure 22.

B. Adjust the probe compensation capacitor for correct compensation, as shown in "C" of Figure 22.

C. Set the VOLTS/DIV switch to the following positions with 1 V and then 10 V square wave signals applied to the inputs. Then adjust the indicated trimmer capacitors for the ideal wave form appearance:

RANGE	ADJUST CAPACITOR
.2 V	VC102 (CHA) or VC202 (CHB)
2 V	*VC105 (CHA) or VC205 (CHB)

* Access to VC105 will require a flexible tool, or you may choose not to alter the factory setting of this capacitor.

Method 2

A. Connect a low-range capacitance meter very directly to the appropriate CHA or CHB input connector. Set the VOLTS/DIV switch to 20 mV, and measure the input capacitance. Then set the VOLTS/DIV switch to the following positions and adjust the indicated trimmer capacitors for the same capacitance value.

RANGE	ADJUST CAPACITOR
.2 V	VC102 (CHA) or VC202 (CHB)
2 V	*VC105 (CHA) or VC205 (CHB)

Triggering Adjustments

NOTE: Perform the following steps only for CHA.

1. CHA trigger offset (X-axis DC level) — Perform the following steps:

   A. Set the CHA AC-GND-DC switch to AC and apply a 1 kHz sine wave signal to the CHA input.

   B. Set the VERT MODE switch to CHA, and set the SOURCE switch to CHA.

   C. Select an appropriate setting for the VOLTS/DIV switch and adjust the input signal amplitude for a deflection of 2 to 4 full divisions, vertically centered exactly on the center line of the screen.

   D. Set the TRIG LEVEL control fully counterclockwise.

   E. Adjust VR569 to position the starting point (left edge of the trace) exactly at the center horizontal graticule line.

* Access to VC105 will require a flexible tool, or you may choose not to alter the factory setting of this capacitor.

2. ALT adjustment — Perform the following steps:

   A. Set the CHA and CHB AC-GND-DC switches to AC.

   B. Set the VERT MODE switch to DUAL.

   C. Set the TRIG SOURCE switch to CHA.

   D. Simultaneously apply a 1 kHz sine wave signal to the CHA input connector and a 10 kHz square wave signal to the CHB input connector. Then adjust the amplitude of each waveform, externally or with the VOLTS/DIV switch, for a peak-to-peak display of one full division (1 cm) on the CRT screen.

   E. Pull out the ALT TRIG switch (CHA ▲▼ POSITION control).

   F. With the TRIG LEVEL control turned fully counterclockwise, adjust VR519 until both displayed waveforms are stably triggered.

Horizontal Amplifier Adjustments

1. Time base calibration — The purpose of the following adjustments is to calibrate the sweep time of the TIME/DIV switch using accurate time intervals of 1 ms, .1 ms, and 1 µs.

   Perform the following steps:

   A. Turn the VAR sweep control fully clockwise to CAL'D.

   B. Apply a time marker signal of 1 ms to the CHA input connector and set the TIME/DIV switch to 1 ms.

   C. Alternately adjust the ◄ ► POSITION and VR719 controls so that the displayed waveform aligns with each vertical graticule line, paying particular attention to the center 8 divisions, as shown in Figure 23.

   D. Change the time interval of the input signal to 1 µs and set the TIME/DIV switch to 1 µs.

   E. Adjust the ◄ ► POSITION control and VC704 so that the displayed waveform again aligns with the vertical graticule lines, as shown in Figure 23, with attention to the center 8 divisions.

NOTE: After you complete the above steps, you may wish to check the TIME/DIV accuracy for each range against those given in the "Specifications" section of this Manual.

2. X10 MAG calibration — Perform the following steps:

   A. Change the time interval of the input signal to .1 ms.

   B. Set the TIME/DIV switch to 1 ms.

   C. Pull out the PULL X10 MAG switch.

   D. Adjust VR655 so the waveform aligns with the vertical graticule lines, as shown in Figure 23.

   E. Push the PULL X10 MAG switch in.

CAL Signal Adjustments

1. Set the VOLTS/DIV switch for CHA to .5 V.
2. Set the VERT MODE switch to CHA.
3. Set the TIME/DIV switch to .5 ms.
4. Connect the CHA input to the front panel CAL test point. Adjust the triggering for a stable display.
5. Set the ◄ ► POSITION control to midrange and pull out the PULL X10 MAG switch.
6. Adjust the VAR (sweep) control until the square wave trace is nearly reduced to a full width of 10 divisions per cycle. Then alternately adjust the VAR (sweep) and ◄ ► POSITION controls until the waveform cycle is exactly 10 divisions per cycle. Measure the portion where the square wave is "high" (positive). The "duty cycle" is then (positive duration) divided by 10. For example, a "high" duration of 4.8 divisions is a duty cycle of 0.48.
7. Calculate a DC adjustment value for the CAL signal based on 2 V times the duty cycle. In the example of step 6 above, this would provide a 0.960 VDC adjustment value.
8. Use a DC voltmeter to measure the DC voltage at the CAL terminal on the front panel. Then adjust VR453 until the DC voltage equals the calculated value in step 7 (±0.005 VDC).
9. Disconnect the voltmeter and CHA input.

X-Y Adjustments

Refer to Figure 24 for the following steps.

1. Set the VERT MODE switch to CHB.
2. Push the X-Y switch button in. Reduce the trace brightness, as required.
3. Adjust VR589 so that the beam spot is horizontally positioned at the center of the CRT screen.
4. X-axis gain — Perform the following steps:

   A. Set the AC-GND-DC switch for CHA and CHB to AC.

   B. Set the VOLTS/DIV switches for CHA and CHB to 50 mV.

   C. Make sure the CHA and CHB VAR controls are both turned fully clockwise to CAL'D.

   D. Apply a .2 V p-p (approximately) sine wave signal to the CHA and CHB input connectors.

   E. Adjust VR516 so that you obtain a trace with a 45° slope, as shown in Figure 24, which passes exactly through the vertical and horizontal graticule line intersections. NOTE: A "touch-up" of VR589 may be required.

5. Pull the X-Y switch button out.

Component Tester Adjustments

1. Set the ◄ ► POSITION control to its midpoint.
2. Push the COMP TEST switch in.
3. Adjust VR375 so the trace is positioned vertically on the center graticule line.
4. Connect a shorting wire between the COMP TEST and GND jacks.
5. Adjust VR379 so the trace is horizontally centered on the center graticule line.
6. Push the COMP TEST switch out and remove the wire between the COMP TEST and GND jacks.

NOTE: After the cabinet is reassembled and the Oscilloscope is on your workbench, a "touch-up" of the front panel TRACE ROT control may be required to reset the trace parallel to the graticule.

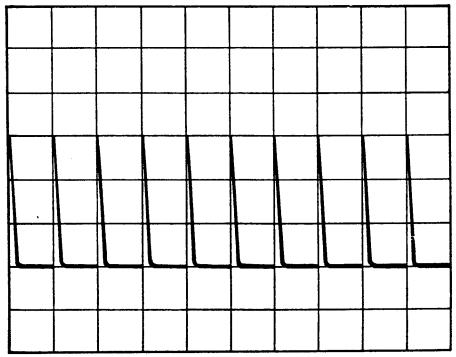


Figure 23

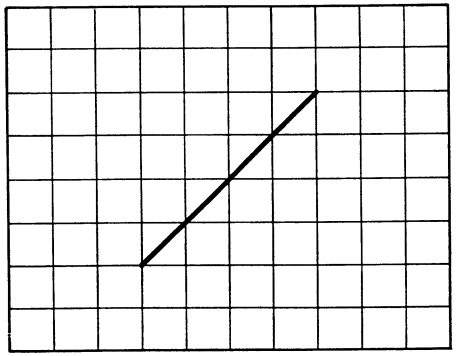
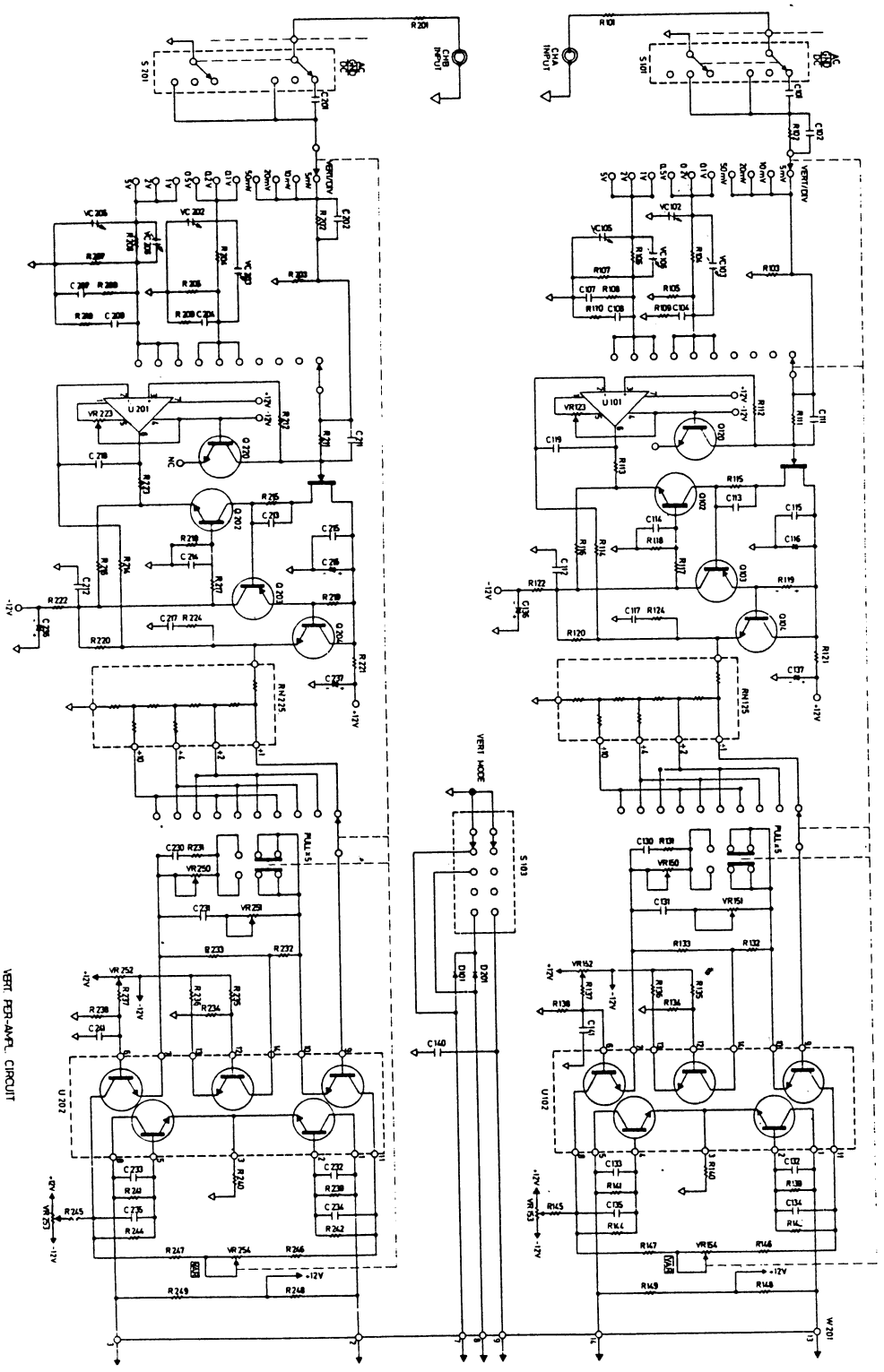


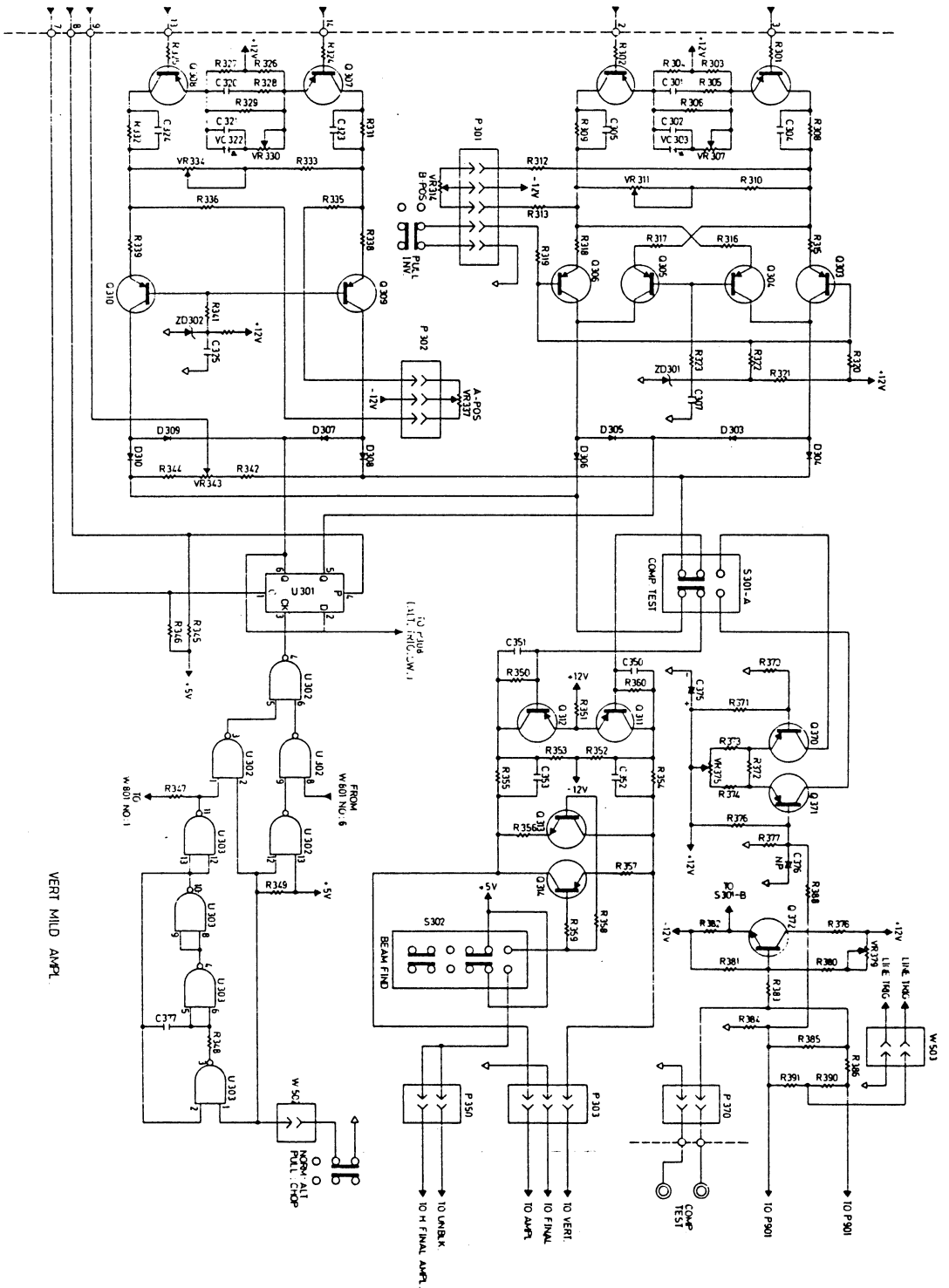
Figure 24

SCHEMATIC DIAGRAMS

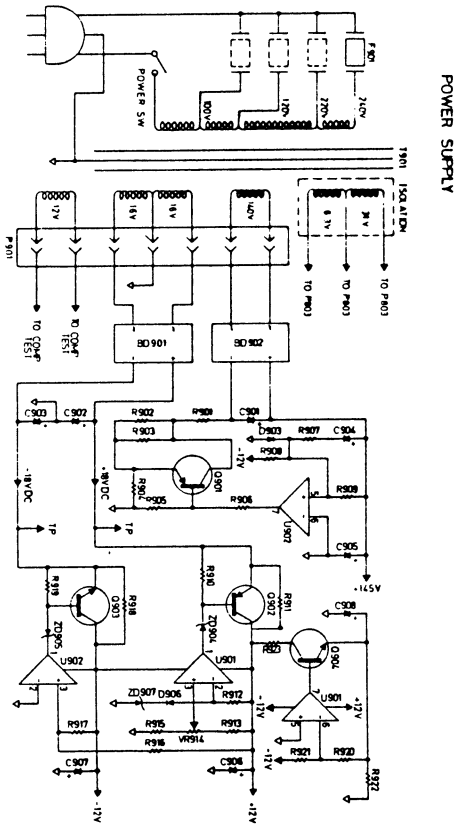


VERT PER-AMPL CIRCUIT

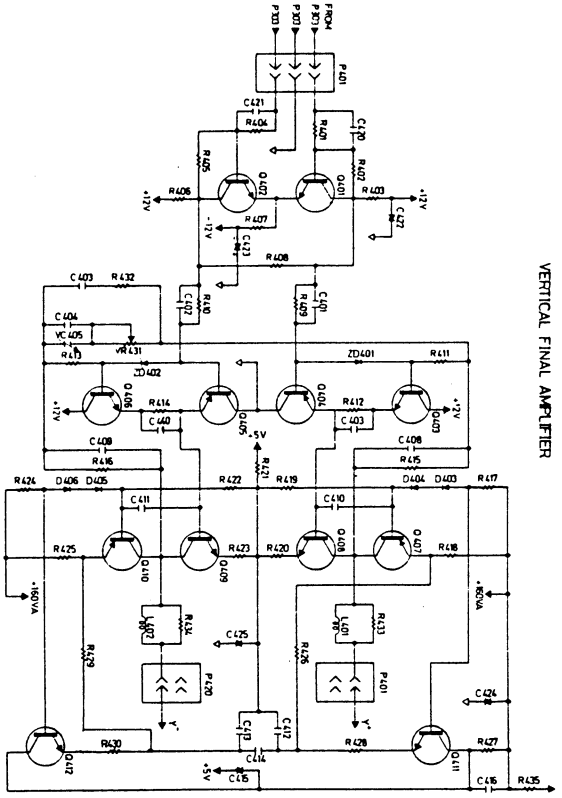
SCHEMATIC DIAGRAMS



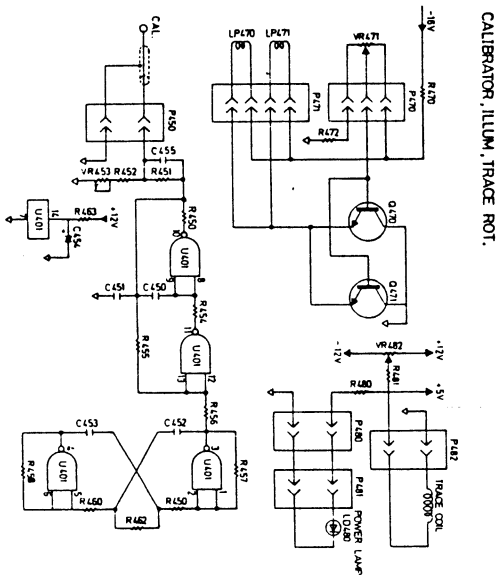
SCHEMATIC DIAGRAMS



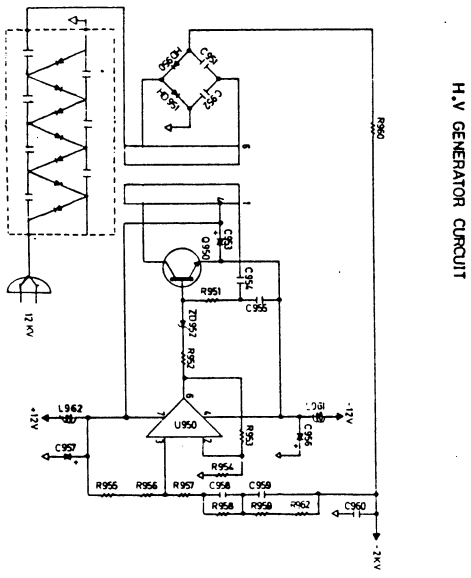
POWER SUPPLY



VERTICAL FINAL AMPLIFIER



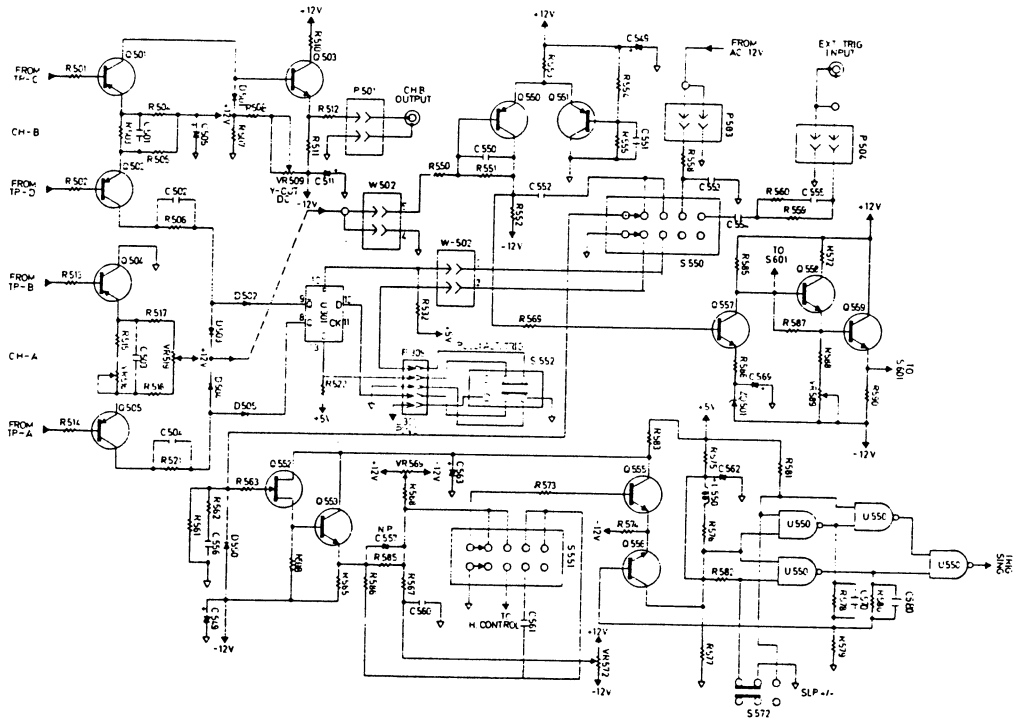
CALIBRATOR, ILLUM, TRACE ROT.



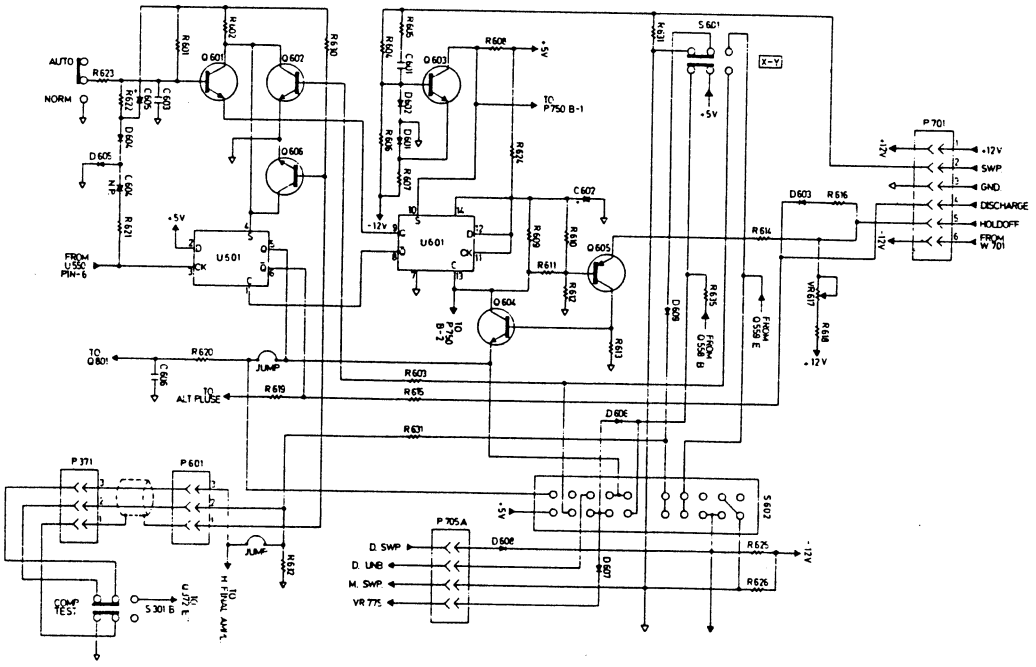
H.V GENERATOR CURCUIT

SCHEMATIC DIAGRAMS

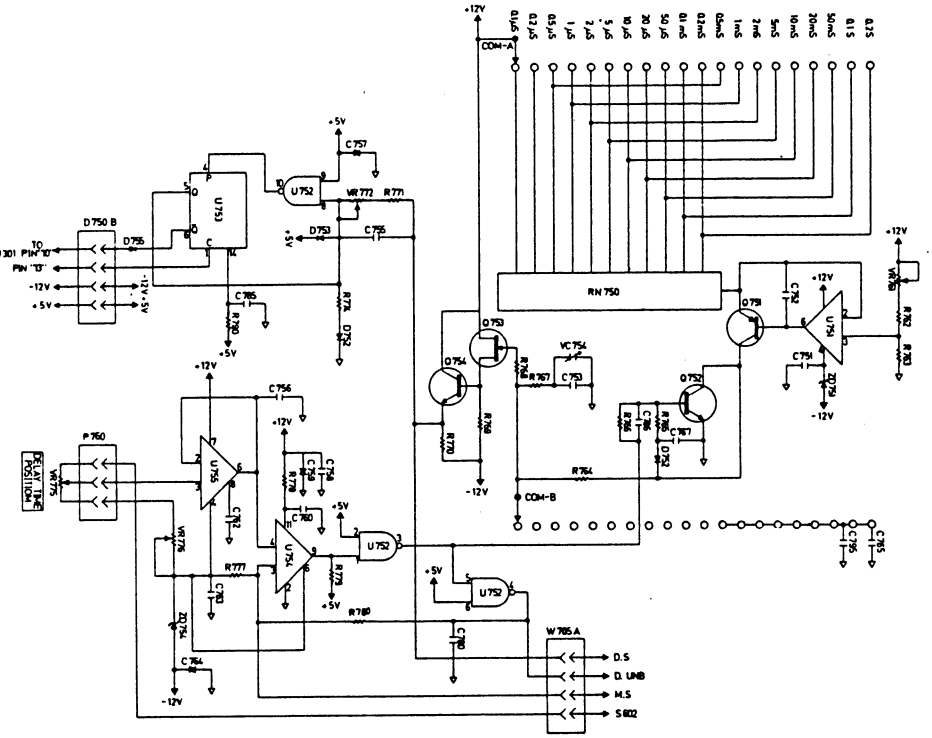
TRIG GENERATOR

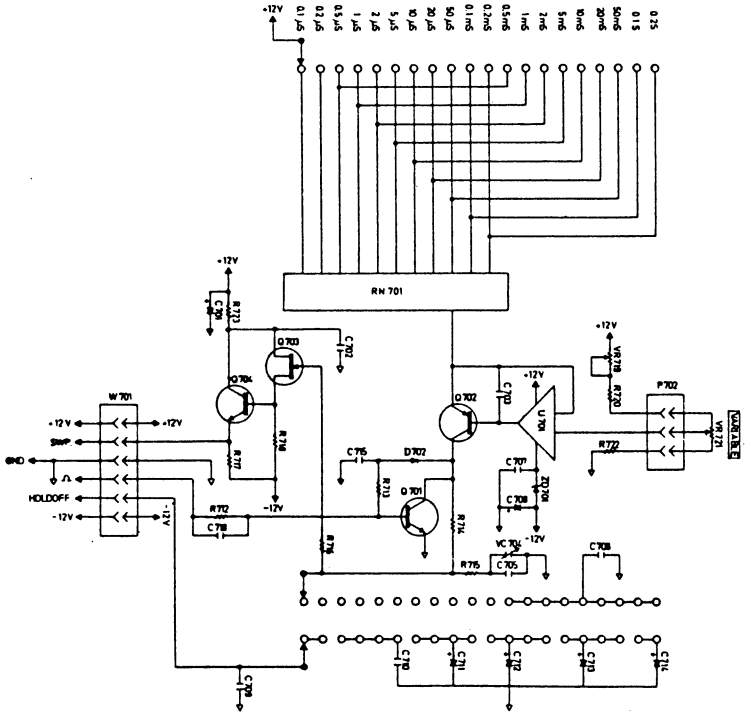


H CONTROL CKT.



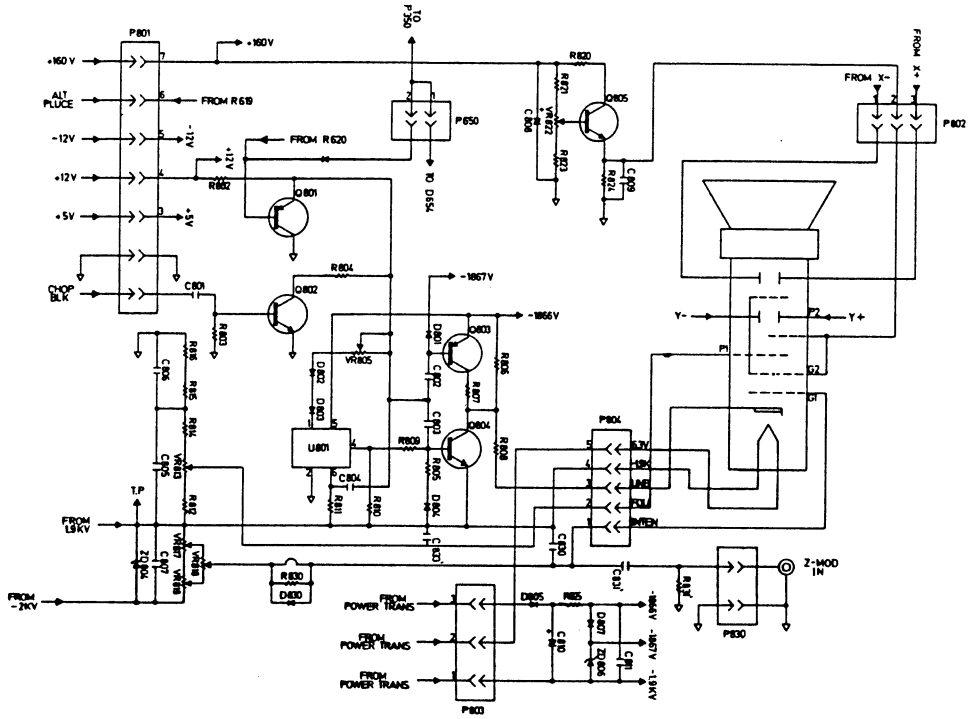
SCHEMATIC DIAGRAMS



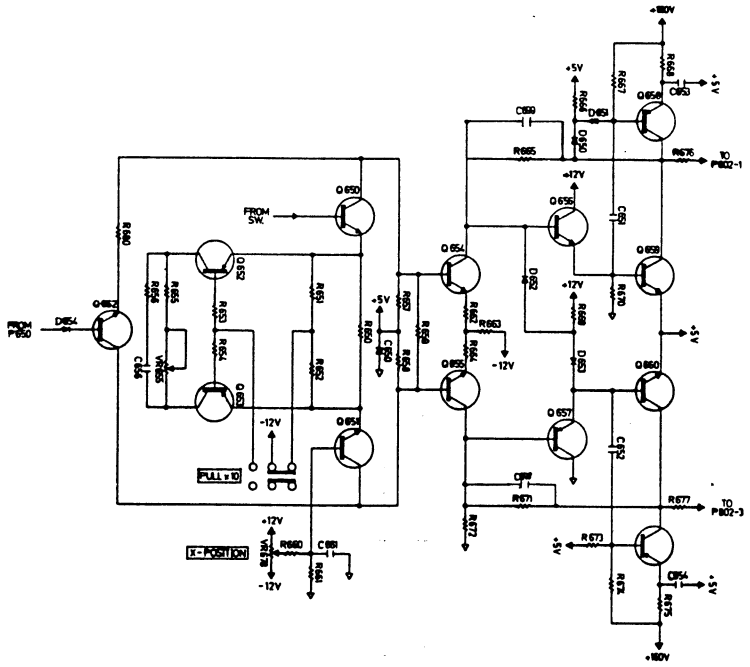


SCHEMATIC DIAGRAMS

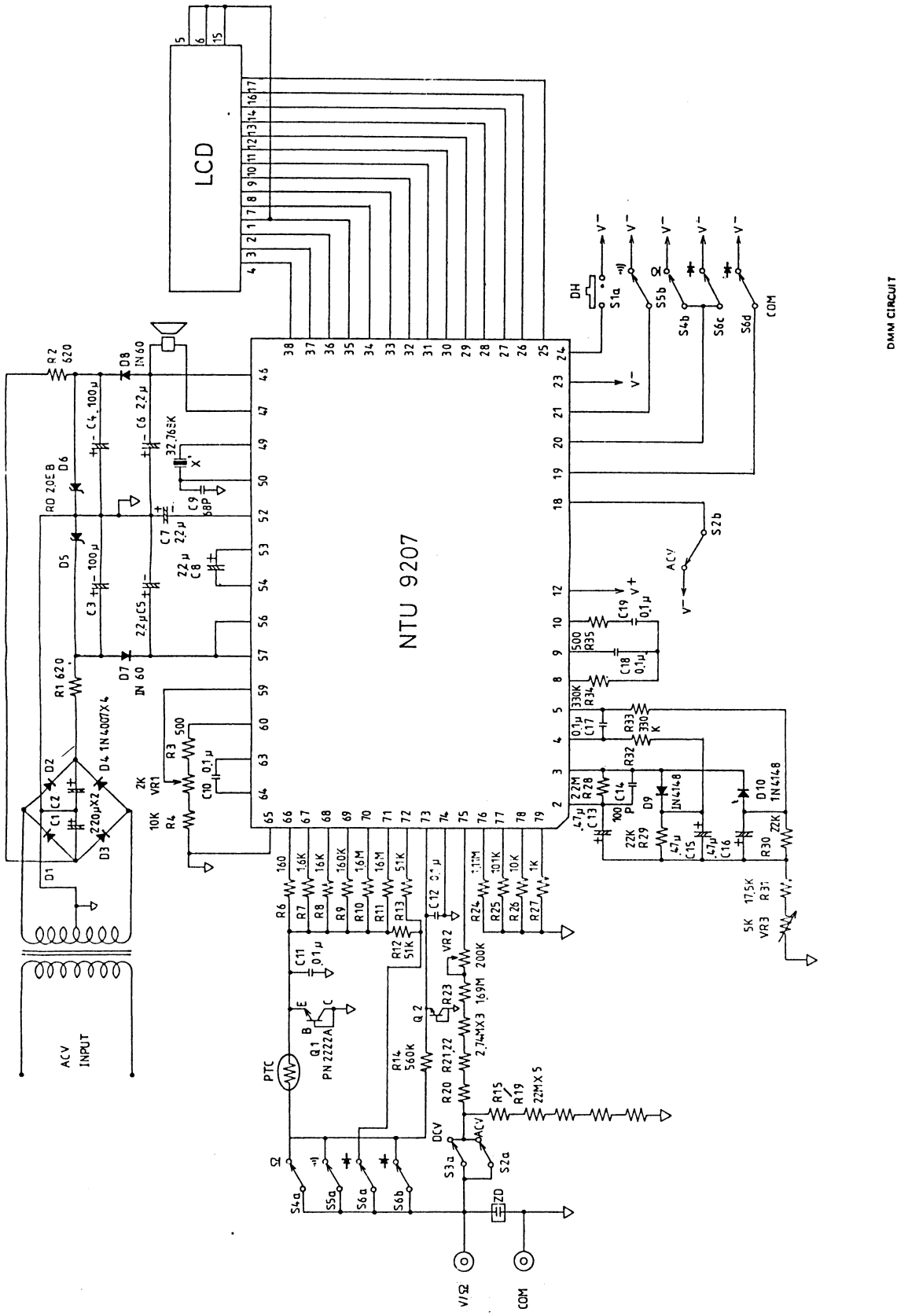
CRT CIRCUIT



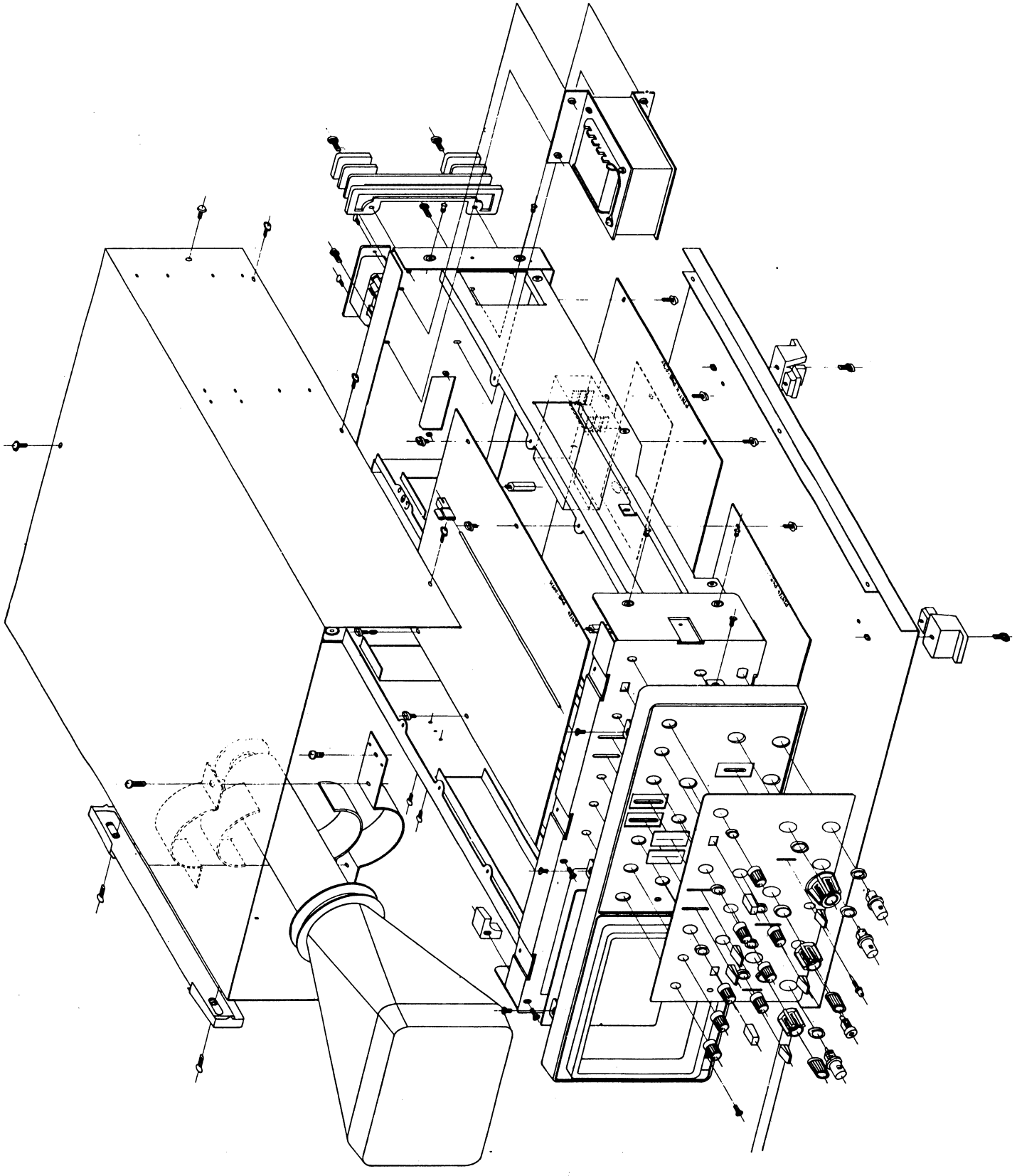
H-FINAL AMPLIFIER



MACHINERY ASSEMBLY DIAGRAM



MACHINERY ASSEMBLY DIAGRAM



PARTS LIST

SCHEMATIC SYMBOL	DESCRIPTION		
VERT. PER-AMPL CIRCUIT (CHA)			
C101	022µF	±10%	630V
VC102	10PF	±20%	50V
VC103	6PF	±20%	50V
C104	33PF	±10%	50V
VC105	10PF	±20%	50V
VC106	6PF	±20%	50V
C107	330PF	±10%	50V
C108	220PF	±10%	50V
C111	.0022µF	±10%	400V
C112	0.022µF	±10%	50V
C113	1000PF	±10%	50V
C114	1000PF	±10%	50V
C115	0.022µF	±10%	50V
C116	10µF	±20%	50V
C119	10PF	±20%	50V
C130	100PF	±20%	50V
VC131	56PF	±20%	50V
C132	5PF	±20%	50V
C133	5PF	±20%	50V
C134	82PF	±20%	50V
C135	82PF	±20%	50V
C136	10µF	±20%	50V
C137	10µF	±20%	50V
C140	.01µF	±10%	50V
C150	150P	±10%	50V
D101	1N4148		
Q101	2SK107	FET	
Q102	2SC945	NPN	
Q103	2SA844	PNP	
Q104	2SC945	NPN	
Q120	2SC1907	NPN	
R101	47Ω	±5%	1/4W
R102	33Ω	±5%	1/4W

SCHEMATIC SYMBOL	DESCRIPTION		
R103	1MΩ	±1%	1/2W
R104	900KΩ	±0.5%	1/2W
R105	111KΩ	±0.5%	1/4W
R106	990KΩ	±0.5%	1/4W
R107	10.1KΩ	±0.5%	1/4W
R108	27Ω	±5%	
R109	68Ω	±5%	1/4W
R110	10Ω	±5%	1/4W
R111	470KΩ	±5%	1/2W
R112	1KΩ	±5%	1/4W
R113	1KΩ	±5%	1/4W
R114	390Ω	±5%	1/4
R115	100Ω	±5%	1/4W
R116	680Ω	±5%	1/4W
R117	3.9KΩ	±5%	1/4W
R118	8.2KΩ	±5%	1/4W
R119	5.6KΩ	±5%	1/4W
R120	1.2KΩ	±5%	1/4W
R121	10Ω	±5%	1/4W
R122	10Ω	±5%	1/4W
VR123	20KΩ	±20%	1/4W
R131	100Ω	±20%	1/4W
R132	120Ω	±20%	1/4W
R133	120Ω	±20%	1/4W
R134	5.6KΩ	±20%	1/4W
R135	5.6KΩ	±20%	1/4W
R136	681Ω	±1%	1/4W
R137	100KΩ	±5%	1/4W
R138	100Ω	±5%	1/4W
R139	475Ω	±1%	1/4W
R140	270Ω	±5%	1/4W
R141	475Ω	±1%	1/4W
R142	56.2Ω	±1%	1/4W
R144	56.2Ω	±1%	1/4W
R145	47KΩ	±5%	1/4W
R146	27Ω	±5%	1/4W

SCHEMATIC SYMBOL	DESCRIPTION		
R147	27Ω	±5%	1/4W
R148	681Ω	±1%	1/4W
R149	681Ω	±1%	1/4W
VR150	100Ω	±20%	1/4W
VR151	500Ω	±20%	1/4W
VR152	20KΩ	±20%	1/4W
VR153	20KΩ	±20%	1/4W
VR154	1KΩ	±20%	1/4W
U101	LF13741N		
U102	CA3086		
VBRT. PER-AMPL CIRCUIT (CHB)			
C201	022μF	±10%	630V
VC202	10PF	±20%	50V
VC203	6PF	±20%	50V
C204	33PF	±10%	50V
VC205	10PF	±20%	50V
VC206	6PF	±20%	50V
C207	330PF	±10%	50V
C208	220PF	±10%	50V
C211	.0022μF	±10%	400V
C212	0.022μF	±10%	50V
C213	1000PF	±10%	50V
C214	1000PF	±10%	50V
C215	.022μF	±10%	50V
C216	10μF	±20%	50V
C218	10PF	±10%	50V
C230	100PF	±10%	50V
VC231	56PF	±10%	50V
C232	5PF	±10%	50V
C233	5PF	±10%	50V
C234	82PF	±10%	50V
C235	82PF	±10%	50V
C236	10μPF	±20%	
C237	10μF	±20%	
C250	150P	±10%	50V
D201	1N4148		
Q201	2SK107		
Q202	2SC945	NPN	

SCHEMATIC SYMBOL	DESCRIPTION		
Q203	2SA844	PNP	
Q204	2SC945	NPN	
Q220	2SC1907	NPN	
R201	47Ω	±5%	
R202	33Ω	±5%	
R203	1MΩ	±1%	
R204	900KΩ	±0.5%	
R205	111KΩ	±0.5%	
R206	990KΩ	±0.5%	
R207	10.1KΩ	±0.5%	1/2W
R208	27Ω	±5%	1/4W
R209	68Ω	±5%	1/4W
R210	10Ω	±5%	1/4W
R211	470KΩ	±5%	1/2W
R212	1KΩ	±5%	1/4W
R213	1KΩ	±5%	1/4W
R214	390Ω	±5%	1/4W
R215	100Ω	±5%	1/4W
R216	680Ω	±5%	1/4W
R217	3.9KΩ	±5%	1/4W
R218	8.2KΩ	±5%	1/2W
R219	5.6KΩ	±5%	1/4W
R220	1.2KΩ	±5%	1/4W
R221	10Ω	±5%	1/4W
R222	10Ω	±5%	1/4W
R223	1KΩ	±20%	
VR223	20KΩ	±5%	1/4W
R231	100Ω	±5%	1/4W
R232	120Ω	±5%	1/4W
R233	120Ω	±5%	1/4W
R234	5.6KΩ	±5%	1/4W
R235	5.6KΩ	±5%	1/4W
R236	681Ω	±1%	1/4W
R237	100KΩ	±5%	1/4W
R238	100Ω	±5%	1/4W
R239	475Ω	±1%	1/4W
R240	270Ω	±5%	1/4W
R241	475Ω	±1%	1/4W
R242	56.2Ω	±1%	1/4W
R244	56.2Ω	±1%	1/4W
R245	47KΩ	±5%	1/4W
R246	27Ω	±5%	1/4W
R247	27Ω	±5%	1/4W

SCHEMATIC SYMBOL	DESCRIPTION		
R248	681Ω	±1%	1/4W
R249	681Ω	±1%	1/4W
VR250	100Ω	±20%	
VR251	500Ω	±20%	
VR252	20KΩ	±20%	
VR253	20Ω	±20%	
VR254	1KΩ	±20%	
U201	LF13741N		
U202	CA3086		
VERT. PER-AMPL CIRCUIT (CHB)			
C301	.0022μF	±10%	50V
C302	68PF	±5%	50V
VC303	50PF	±20%	50V
C304	.01μF	±10%	50V
C305	.01μF	±10%	50V
C307	.01PF	±10%	50V
C320	.0022μF	±10%	50V
C321	68P	±5%	50V
VC322	50PF	±20%	400V
C323	.01μF	±10%	50V
C324	.01μF	±10%	630V
C325	.01μF	±5%	50V
C330	10μF	±20%	25V
C338	10μF	±20%	25V
C350	3PF	±5%	50V
C351	3PF	±5%	50V
C352	47PF	±5%	50V
C353	47PF	±5%	50V
C360	100PF	±20%	400V
C375	10μF	±20%	50V
C376	10μF	±20%	50V
C377	10μF	±10%	50V
C378	10μF	±10%	50V
C380	10μF	±20%	25V
C386	470PF	±10%	50V
C387	1000PF	±10%	50V
C388	2200PF	±10%	50V
ZD301	HZ3C2		
ZD302	HZ3C2		
D303	1N4148		
D304	1N4148		

SCHEMATIC SYMBOL	DESCRIPTION		
D305	1N4148		
D306	1N4148		
D307	1N4148		
D308	1N4148		
D309	1N4148		
D310	1N4148		
Q301	2SA1206	PNP	
Q302	2SA1206	PNP	
Q303	2SA838	PNP	
Q304	2SA838	PNP	
Q305	2SA838	PNP	
Q306	2SA838	PNP	
Q307	2SA1206	PNP	
Q308	2SA1206	PNP	
Q309	2SA838	PNP	
Q310	2SA838	PNP	
Q311	2SA1206	PNP	
Q312	2SA1206	PNP	
Q313	2SC535	NPN	
Q314	2SC535	NPN	
Q370	2SC838	PNP	
Q371	2SC838	PNP	
Q372	2SC1815		
R301	47Ω	±5%	1/4W
R302	47Ω	±5%	1/4W
R303	1.5KΩ	±5%	1/4W
R304	1.5KΩ	±5%	1/4W
R305	7.5KΩ	±5%	1/4W
R306	91Ω	±5%	1/4W
VR307	500Ω	±20%	1/4W
R308	180Ω	±5%	1/4W
R309	180Ω	±5%	1/4W
R310	120Ω	±5%	1/4W
VR311	1KΩ	±20%	
R312	5.6KΩ	±5%	1/4W
R313	5.6KΩ	±5%	1/4W
VR314	10KΩ	±20%	
R315	33Ω	±5%	1/4W
R316	33Ω	±5%	1/4W
R317	33Ω	±5%	1/4W
R318	33Ω	±5%	1/4W
R319	909Ω	±1%	1/4W
R320	6.8KΩ	±5%	1/4W

SCHEMATIC SYMBOL	DESCRIPTION		
R321	2.2KΩ	±5%	1/4W
R322	220Ω	±5%	1/4W
R323	22Ω	±5%	1/4W
R324	47Ω	±5%	1/4W
R325	47Ω	±5%	1/4W
R326	1.5KΩ	±5%	1/4W
R327	1.5KΩ	±5%	1/4W
R328	7.5Ω	±5%	1/4W
R329	91Ω	±5%	1/4W
VR330	500Ω	±20%	
R331	180Ω	±5%	1/4W
R332	180Ω	±5%	1/4W
R333	120Ω	±5%	1/4W
VR334	1KΩ	±20%	
R335	5.6KΩ	±5%	1/4W
R336	5.6KΩ	±5%	1/4W
R338	33Ω	±5%	1/4W
R339	33Ω	±5%	1/4W
R340	5.6KΩ	±5%	1/4W
R341	22Ω	±5%	1/4W
R342	330Ω	±5%	1/4W
VR343	330Ω	±5%	1/4W
R344	330Ω	±5%	1/4W
R345	47KΩ	±5%	1/4W
R346	47KΩ	±5%	1/4W
R347	220Ω	±5%	1/4W
R348	4.7KΩ	±5%	1/4W
R349	47KΩ	±5%	1/4W
R350	475Ω	±5%	1/4W
R351	1KΩ	±5%	1/4W
R352	820Ω	±5%	1/4W
R353	820Ω	±5%	1/4W
R354	82Ω	±5%	1/4W
R355	82Ω	±5%	1/4W
R356	56Ω	±5%	1/4W
R357	56Ω	±5%	1/4W
R358	2.7KΩ	±5%	1/4W
R359	2.7KΩ	±5%	1/4W
R360	475Ω	±5%	1/4W
R361	6.8Ω	±5%	1/4W
R362	6.8Ω	±5%	1/4W

SCHEMATIC SYMBOL	DESCRIPTION		
R363	6.8Ω	±5%	1/4W
R370	1KΩ	±5%	1/4W
R373	2.2KΩ	±5%	1/4W
R374	2.2KΩ	±5%	1/4W
VR375	500Ω	±20%	
R378	1KΩ	±5%	1/4W
VR379	500KΩ	±20%	
R380	470KΩ	±5%	1/4W
R381	1MΩ	±5%	1/4W
R382	10KΩ	±5%	1/4W
R383	3.3MΩ	±5%	1/4W
R384	51Ω	±5%	1/4W
R385	1KΩ	±5%	1/4W
R386	1KΩ	±5%	1/4W
R388	560Ω	±5%	1/4W
R390	15KΩ	±5%	1/4W
R391	1KΩ	±5%	1/4W
R395	10Ω	±5%	1/4W
U301	74LS74		
U302	CD4011		
U303	CD4011		

VERTICAL FINAL AMPLIFIER

C401	27PF	±10%	50V
C402	27PF	±10%	50V
C403	.01μF	±10%	50V
VC405	27PF	±10%	50V
C440	.01μF	±10%	50V
C407	.01μF	±10%	50V
C408	.47PF	±10%	50V
C409	.47PF	±10%	50V
C410	.047μF	±10%	250V
C411	.047μF	±10%	250V
C412	.022μF	±10%	50V
C413	.022μF	±10%	50V
C414	.047μF	±10%	50V
C415	1μF	±20%	200V
C416	1μF	±10%	50V

SCHEMATIC SYMBOL	DESCRIPTION		
C420	10PF	±10%	50V
C421	10PF	±10%	50V
C422	10μF	±20%	25V
C423	10μF	±20%	25V
C424	1μF	±20%	200V
C425	10μF	±20%	25V
ZD401	HB-2B-3		
ZD402	HB-2B-3		
D403	1N4148		
D404	1N4148		
D405	1N4148		
D406	1N4148		
L401	33μF		
L402	33μF		
Q401	2SC1907	NPN	
Q402	2SC1907	NPN	
Q403	2SC1907	NPN	
Q404	2SA1206	PNP	
Q405	2SA1206	PNP	
Q406	2SC1907	NPN	
Q407	649A	PNP	
Q408	669A	NPN	
Q409	669A	NPN	
Q410	649A	PNP	
Q411	2SC2570	NPN	
Q412	2SC2570	NPN	
R401	90.9Ω	±1%	1/4W
R402	475Ω	±1%	1/4W
R403	680Ω	±5%	1/4W
R404	90.9Ω	±1%	1/4W
R405	475Ω	±1%	1/4W
R406	680Ω	±5%	1/4W
R407	1KΩ	±5%	1/4W
R408	1.5KΩ	±5%	1/4W
R409	470Ω	±5%	1/4W
R410	470Ω	±5%	1/4W
R411	220Ω	±5%	1/4W
R412	22Ω	±5%	1/4W
R413	220Ω	±5%	1/4W
R414	22Ω	±5%	1/4W
R415	33KΩ	±1%	1/4W

SCHEMATIC SYMBOL	DESCRIPTION		
R416	33KΩ	±1%	1/4W
R417	3.3KΩ	±5%	1/4W
R418	1KΩ	±5%	1/4W
R419	47KΩ	±5%	1/4W
R420	4.7Ω	±5%	1/4W
R421	10Ω	±5%	1/4W
R422	47KΩ	±5%	1/4W
R423	4.7KΩ	±5%	1/4W
R424	3.3KΩ	±5%	1/4W
R425	1KΩ	±5%	1/4W
R426	4.7Ω	±5%	1/4W
R427	82Ω	±5%	1/4W
R428	4.7Ω	±5%	1/4W
R429	4.7Ω	±5%	1/4W
R430	4.7Ω	±5%	1/4W
VR431	2.2KΩ	±20%	
R432	33KΩ	±5%	1/4W
R433	470Ω	±5%	1/4W
R434	470Ω	±5%	1/4W
R435	10Ω	±5%	1/4W

CALIBRATOR, ILLUM, TRACE ROT.

C450	5PF	±10%	50V
C451	1000PF	±10%	50V
C452	.01μF	±10%	50V
C453	.01μF	±10%	50V
C454	10μF	±20%	25V
C455	1000PF	±10%	50V
Q470	2SC1162	NPN	
Q471	2SX1162	NPN	
R450	10K	±5%	1/4W
R451	10KΩ	±10%	1/4W
R452	3.3K	±10%	1/4W
VR453	2.2KΩ	±5%	1/4W
R454	470KΩ	±5%	1/4W
R455	470KΩ	±5%	1/4W
R456	220KΩ	±5%	1/4W
R457	100KΩ	±5%	1/4W
R458	75KΩ	±5%	1/4W
R459	4.7KΩ	±5%	1/4W

SCHEMATIC SYMBOL	DESCRIPTION		
R460	10KΩ	±5%	1/4W
R462	180K	±5%	1/4W
R463	10Ω	±5%	1/4W
VR471	10KΩ	±20%	1/4W
R472	1.5KΩ	±5%	1/4W
R480	100Ω	±5%	1/4W
R481	100Ω	±5%	1/4W
VR482	2.2KΩ	±20%	1/4W
U401	CD4011		
TRIG GENERATOR			
C501	180P	±10%	50V
C502	0.01PF	±10%	50V
C503	180PF	±10%	50V
C504	0.01	±10%	50V
C505	10μF	±20%	25V
C511	10μF	±20%	25V
C548	10μF	±20%	25V
C549	10μF	±20%	25V
C550	10P	±10%	50V
C551	.01μF	±10%	50V
C552	1μF	±10%	50V
C553	1000DF	±10%	50V
C554	.047μF	±10%	400V
C555	22PF	±10%	500V
C557	10μF	±20%	25V
C560	.01μF	±10%	50V
C561	.1μF	±10%	50V
C562	47μF	±20%	50V
C563	10μF	±20%	25V
C565	10μF	±20%	25V
C578	3P	±10%	50V
C580	3P	±10%	50V
D501	1N4148		
ZD501	HZ9C1		
D502	1N4148		
D503	1N4148		
D504	1N4148		
D505	1N4148		

SCHEMATIC SYMBOL	DESCRIPTION		
D550	1N4148		
D551	1N4148		
L550	6.8μF		
Q501	2SA1206	PNP	
Q502	2SA1206	PNP	
Q503	2SC1907	NPN	
Q504	2SA1206	PNP	
Q505	2SA1206	PNP	
Q550	2SA838	PNP	
Q551	2SA838	PNP	
Q552	2SK404E	FET	
Q553	2SC458	NPN	
Q555	2SC535C	NPN	
Q556	2SC535C	NPN	
Q557	2SC1907	NPN	
Q558	2SA1206	PNP	
Q559	2SC1907	NPN	
R501	100Ω	±5%	1/4W
R502	100Ω	±5%	1/4W
R503	33Ω	±5%	1/4W
R504	1.5KΩ	±5%	1/4W
R505	1.5KΩ	±5%	1/4W
R506	220Ω	±5%	1/4W
R507	1KΩ	±5%	1/4W
R508	2.7KΩ	±5%	1/4W
VR509	2.2KΩ	±20%	
R510	10Ω	±5%	1/4W
R511	1.5KΩ	±5%	1/4W
R512	51Ω	±1%	1/4W
R513	100Ω	±5%	1/4W
R514	100Ω	±5%	1/4W
R515	22Ω	±5%	1/4W
VR516	100Ω	±20%	
R517	1KΩ	±5%	1/4W
R518	1KΩ	±5%	1/4W
VR519	1KΩ	±20%	
R521	220Ω	±5%	1/4W
R522	47KΩ	±5%	1/4W
R523	47KΩ	±5%	1/4W
R550	47Ω	±5%	1/4W

SCHEMATIC SYMBOL	DESCRIPTION		
R551	1KΩ	±1%	1/4W
R552	1.5K	±5%	1/4W
R553	1KΩ	±5%	1/4W
R554	8.2KΩ	±5%	1/4W
R555	2.7KΩ	±5%	1/4W
R558	390Ω	±5%	1/4W
R559	470KΩ	±5%	1/4W
R560	68Ω	±5%	1/4W
R561	470KΩ	±5%	1/4W
R563	100Ω	±5%	1/4W
R565	2.7KΩ	±5%	1/4W
R567	15KΩ	±5%	1/4W
R568	15KΩ	±5%	1/4W
R569	1KΩ	±5%	1/4W
VR569	10KΩ	±20%	1/4W
VR572	10KΩ	±5%	1/4W
R573	100Ω	±5%	1/4W
R574	1.5KΩ	±5%	1/4W
R575	10Ω	±5%	1/4W
R576	680Ω	±5%	1/4W
R577	2.7KΩ	±5%	1/4W
R578	10KΩ	±5%	1/4W
R579	120Ω	±5%	1/4W
R580	10KΩ	±5%	1/4W
R581	47KΩ	±5%	1/4W
R582	47KΩ	±5%	1/4W
R583	10Ω	±5%	1/4W
R584	10Ω	±5%	1/4W
R585	1KΩ	±5%	1/4W
R586	560Ω	±5%	1/4W
R587	10KΩ	±5%	1/4W
R588	3.3KΩ	±5%	1/4W
VR589	2.2KΩ	±20%	
R590	1KΩ	±5%	1/4W
R595	1KΩ	±5%	1/4W
R596	1KΩ	±5%	1/4W
R598	10KΩ	±5%	1/4W

SCHEMATIC SYMBOL	DESCRIPTION		
R599	10KΩ	±5%	1/4W
U301	74LS74		
U550	74 SOON		
HOR. CONTROL CKT.			
C601	120PF	±10%	50V
C602	10μF	±20%	25V
C603	.022μF	±10%	50V
C604	1μF	±20%	25V
C605	1μF	±20%	25V
C606	180PF	±10%	50V
D601	1N4148		
D602	1N4148		
D603	1N4148		
D604	1N4148		
D605	1N4148		
D606	1N4148		
D607	1N4148		
D608	1N4148		
D609	1N4148		
Q601	2SC1815	NPN	
Q602	2SC1815	NPN	
Q603	2SC1815	NPN	
Q604	2SC1815	NPN	
Q605	2SA1029	PNP	
Q606	2SC1815	NPN	
R601	100KΩ	±5%	1/4W
R602	4.7KΩ	±5%	1/4W
R603	10KΩ	±5%	1/4W
R604	1KΩ	±5%	1/4W
R605	100Ω	±5%	1/4W
R606	2.2KΩ	±5%	1/4W
R607	4.7KΩ	±5%	1/4W
R608	10KΩ	±5%	1/4W
R609	10KΩ	±5%	1/4W
R610	2.2KΩ	±5%	1/4W
R611	22KΩ	±5%	1/4W
R612	1.5KΩ	±5%	1/4W
R613	100KΩ	±5%	1/4W
R614	1.5KΩ	±5%	1/4W

SCHEMATIC SYMBOL	DESCRIPTION		
R615	51Ω	±5%	1/4W
R616	470Ω	±5%	1/4W
VR617	10KΩ	±20%	1/4W
R618	10K	±5%	1/4W
R619	1KΩ	±5%	1/4W
R620	220Ω	±5%	1/4W
R621	270Ω	±5%	1/4W
R622	10KΩ	±5%	1/4W
R623	10KΩ	±5%	1/4W
R624	10Ω	±5%	1/4W
R625	5.6KΩ	±5%	1/4W
R626	5.6KΩ	±5%	1/4W
R630	100KΩ	±5%	1/4W
R631	1KΩ	±5%	1/4W
R632	1KΩ	±5%	1/4W
R635	47Ω	±5%	1/4W
U601	74LS74		
H-FINAL AMPLIFIER			
C650	10μF	±20%	50V
C651	.01μF	±10%	500V
C652	.01μF	±10%	500V
C653	.01μF	±10%	500V
C654	.01μF	±10%	500V
C656	330PF	±10%	50V
C661	1000PF	±10%	50V
C670	33PF	±10%	50V
C680	1μF	±10%	50V
C698	0.2PF	±10%	50V
C699	0.2PF	±10%	50
D650	1N4148		
D651	1N4148		
D652	1N4148		
D653	1N4148		
D654	1N4148		
Q650	2SC945	NPN	
Q651	2SC945	NPN	
Q652	2SA1015	PNP	
Q653	3SA1015	PNP	
Q654	2SC1907	NPN	
Q655	2SC1907	NPN	
Q656	2SC1907	NPN	

SCHEMATIC SYMBOL	DESCRIPTION		
Q657	2SA838	PNP	
Q658	2SB649	PNP	
Q659	2SD669	NPN	
Q660	2SD669	NPN	
Q661	2SB649	PNP	
Q662	2SC1815	NPN	
R650	1.5K	±5%	1/4W
R651	5.6KΩ	±5%	1/4W
R652	5.6KΩ	±5%	1/4W
R653	5.6KΩ	±5%	1/4W
R654	5.6KΩ	±5%	1/4W
R655	68Ω	±5%	1/4W
VR655	100Ω	±20%	
R656	22Ω	±5%	1/4W
R657	1KΩ	±1%	1/4W
R658	1KΩ	±1%	1/4W
R659	620Ω	±5%	1/4W
R660	1.8K	±5%	1/4W
R661	750Ω	±5%	1/4W
R662	330Ω	±5%	1/4W
R663	12KΩ	±5%	1/4W
R664	330Ω	±5%	1/4W
R665	100KΩ	±1%	1/4W
R666	100KΩ	±5%	1/4W
R667	2.2KΩ	±5%	1/4W
R668	330Ω	±5%	1/4W
R669	2.2KΩ	±5%	1/4W
R670	2.2KΩ	±5%	1/4W
R671	100KΩ	±1%	1/4W
R672	100KΩ	±5%	1/4W
R673	100KΩ	±5%	1/4W
R674	2.2KΩ	±5%	1/4W
R675	330Ω	±5%	1/4W
R676	47Ω	±5%	1/4W
R677	47Ω	±5%	1/4W
R678	10KΩ	±20%	
R680	270Ω	±5%	1/4W
R690	1KΩ		
TIME BASE CIRCUIT			
C701	10μF	±20%	25V
C702	.022μF	±10%	50V

SCHEMATIC SYMBOL	DESCRIPTION		
C703	.01μF	±10%	50V
VC704	50PF	±10%	50V
C705	910PF	±5%	50V
C706	1μF	±5%	100V
C707	.022μF	±10%	50V
C708	10μF	±20%	25V
C709	330PF	±10%	50V
C710	470PF	±10%	50V
C711	.33μF	±20%	100V
C712	4.7μF	±20%	25V
C713	47μF	±20%	25V
C714	470μF	±20%	25V
C715	47PF	±10%	50V
ZD701	HZ6B1		
D702	1N4148		
Q701	BSX20		
Q702	2SA1051	PNP	
Q703	2SK404		
Q704	2SC458	NPN	
R712	4.7KΩ	±5%	1/4W
R713	15KΩ	±5%	1/4W
R714	51Ω	±5%	1/4W
R715	39Ω	±5%	1/4W
R716	51Ω	±5%	1/4W
R717	1.8KΩ	±5%	1/4W
R718	10KΩ	±5%	1/4W
VR719	100KVR	±20%	
R720	68KΩ	±5%	1/4W
VR721	100KB	±20%	
R722	270KΩ	±5%	1/4W
R723	10Ω	±1%	1/4W
R726	4.7KΩ	±5%	1/4W
U701	TL081		
CRT CIRCUIT			
C801	120PF	±10%	50V
C802	68PF	±10%	3KV
C803	68PF	±10%	3KV
C804	68PF	±10%	3KV
C805	.22μF	±20%	1KV
C806	.22μF	±20%	1KV

SCHEMATIC SYMBOL	DESCRIPTION		
C807	.33μF	±10%	100V
C808	2.2μF	±20%	200V
C809	.047μF	±10%	200V
C810	10μF	±20%	50V
C811	.1μF	±10%	50V
C830	100PF	±10%	50V
C831	4700PF	±10%	3KV
C833	.01μF	±10%	500V
D801	1N4148		
D802	1N4148		
D803	1N4148		
D804	1N4148		
ZD804	ZPY100		
D805	1N4003		
ZD806	RD33EB		
D807	1N4148		
D809	1N4148		
D830	1N4148		
Q801	2SA1015	PNP	
Q802	2SC1815	NPN	
Q803	2SA1029	PNP	
Q804	2SC1815	NPN	
Q805	BF422		
R802	2.2KΩ	±5%	1/4W
R803	10KΩ	±5%	1/4W
R804	100Ω	±5%	1/4W
R805	330Ω	±5%	1/4W
VR805	5KΩ	±20%	
R806	220KΩ	±5%	1/4W
R807	51Ω	±5%	1/4W
R808	51Ω	±5%	1/4W
R809	10KΩ	±5%	1/4W
R810	10KΩ	±5%	1/4W
R811	680KΩ	±5%	1/4W
R812	390K	±5%	1W
VR813	500KΩ	±20%	
R814	2.2MΩ	±5%	1W
R815	1.5MΩ	±5%	1/2W
R816	2.2MΩ	±5%	1W
VR817	500KΩ	±20%	
VR818	500KΩ	±20%	
VR819	500KΩ	±20%	
R820	10KΩ	±5%	1/4W

SCHEMATIC SYMBOL	DESCRIPTION		
R821	100KΩ	±5%	1/4W
VR822	100KΩ	±20%	
R823	10KΩ	±5%	1/4W
R824	120KΩ	±5%	1/4W
R825	4.7KΩ	±5%	1/4W
R830	100KΩ	±5%	1/4W
R831	1MΩ	±5%	1/4W
U801	4N25		
POWER SUPPLY			
C901	47μF	±20%	200V
C902	1000μF	±20%	25V
C903	1000μF	±20%	25V
C904	1μF	±20%	200V
C905	2.2μF	±20%	200V
C906	47μF	±20%	25V
C907	47μF	±20%	25V
C908	47μF	±20%	25V
D903	1N4148		
ZD904	HZ12B1		13V
ZD905	HZ12B1		13V
D906	1N4148		
ZD907	HZ6B1		5.6V
Q901	2SB861	PNP	
Q902	2SB861	PNP	
Q903	2SD880	NPN	
Q904	2SD880	NPN	
R901	82KΩ	±5%	1W
R902	2.7KΩ	±5%	2W
R903	2.7KΩ	±5%	2W
R904	4.7Ω	±5%	1/4W
R905	100Ω	±5%	1/4W
VR905	100Ω	±5%	1/4W
R906	220Ω	±5%	1/4W
R907	560Ω	±5%	1/4W
R908	10KΩ	±1%	1/4W
R909	121KΩ	±1%	1/4W
R910	470Ω	±5%	1/4W
R911	33Ω	±5%	2W
R912	5.6KΩ	±5%	1/4W
R913	5.6KΩ	±5%	1/4W
VR914	1KΩ	±5%	1/4W

SCHEMATIC SYMBOL	DESCRIPTION		
R915	5.6KΩ	±5%	1/4W
R916	12.1KΩ	±1%	1/4W
R917	12.1KΩ	±1%	1/4W
R918	82Ω	±5%	1W
R919	470Ω	±5%	1/4W
R920	5.11K	±1%	1/4W
R921	12.1KΩ	±5%	1/4W
R922	150Ω	±5%	1/2W
R923	82Ω	±5%	1/4W
U901	UPC4558		
U902	UPC4558		
H.V GENERATOR CIRCUIT			
C951	4700PF	±10%	3KV
C952	4700PF	±10%	3KV
C953	100μF	±20%	50V
C954	.1μF	±10%	100V
C955	.1μF	±10%	100V
C956	100μF	±20%	25V
C957	10μF	±20%	25V
C958	68μF	±10%	3KV
C959	4700PF	±10%	3KV
C960	4700PF	±10%	3KV
HD950	R3000		
HD951	R3000		
ZD952	HZ12B1		12V
Q950	BD237		
R951	150Ω	±5%	1/4W
R952	510Ω	±5%	1/4W
R953	10MΩ	±5%	1/4W
R954	10KΩ	±5%	1/4W
R955	33KΩ	±5%	1/4W
R956	43.2KΩ	±5%	1/4W
R957	22KΩ	±5%	1/4W
R958	1.5MΩ	±5%	1/2W
R959	3.3MSL	±5%	1/4W
R960	270Ω	±5%	1/4W
R962	3.3MΩ	±5%	1/4W
U950	LM741CN		
L961	68μH	±5%	1/4W
L962	68μH	±5%	1/4W